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REPORT FOR CONSULTATION ON THE METROPOLITAN CHICAGO INTERSTATE AIR QUALITY CONTROL REGION (INDIANA-ILLINOIS)

National Air Pollution Control Administration
Washington, D. C.

September 1968

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
National Air Pollution Control Administration

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PREFACE

The Secretary, Department of Health, Education, and Welfare, is directed by the Air Quality Act of 1967 to designate "air quality control regions" to provide a basis for the establishment of air quality standards and the implementation of air quality control programs. In addition to listing the major factors to be considered in the development of region boundaries, the Act stipulates that the designation of a region shall be preceded by consultation with appropriate State and local authorities.

The National Air Pollution Control Administration, DHEW, has conducted a study of the Metropolitan Chicago Area, the results of which are presented in this report. The Region* boundaries proposed in this report reflect consideration of all available and pertinent data; however, the boundaries remain subject to revisions suggested during consultation with State and local authorities. Formal designation of a Region will follow the consultation meeting. This report is intended to serve as background material for the consultation.

The Administration appreciates assistance received either directly during the course of this study or indirectly during previous activities in the Chicago Metropolitan Area from the official air pollution agencies, The Northeastern Illinois Planning Commission, the Lake-Porter County Regional Transportation and Planning Commission, the Chicago Area Transportation Study, and the Planning Departments of Chicago and Gary.

*For the purposes of this report, the word region, when capitalized, will refer to the Metropolitan Chicago Interstate Air Quality Control Region. When not capitalized, unless otherwise noted, it will refer to air quality control regions in general.

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INTRODUCTION

> "For the purpose of establishing ambient air quality standards pursuant to section 108, and for administrative and other purposes, the Secretary, after consultation with appropriate State and local authorities shall, to the extent feasible, within 18 months after the date of enactment of the Air Quality Act of 1967 designate air quality control regions based on jurisdictional boundaries, urban-industrial concentrations, and other factors including atmospheric areas necessary to provide adequate implementation of air quality standards. The Secretary may from time to time thereafter, as he determines necessary to protect the public health and welfare and after consultation with appropriate State and local authorities, revise the designation of such regions and designate additional air quality control regions. The Secretary shall immediately notify the Governor or Governors of the affected State or States of such designation."
>
> Section 107 (a) (2), Air Quality Act of 1967

THE AIR QUALITY ACT

Air pollution in most of the Nation's urban areas is a regional problem. Consistent with the problem, the solution demands coordinated regional planning and regional effort. Yet, with few exceptions, such coordinated efforts are notable by their absence in the Nation's urban complexes.

Beginning with the Section quoted above, in which the Secretary is required to designate air quality control regions, the Air Quality Act presents an approach to air pollution control involving closely coordinated efforts by Federal, State, and local governments, as shown in Figure 1. After the Secretary has (1) designated regions, (2) published air quality criteria, and (3) published corresponding documents on

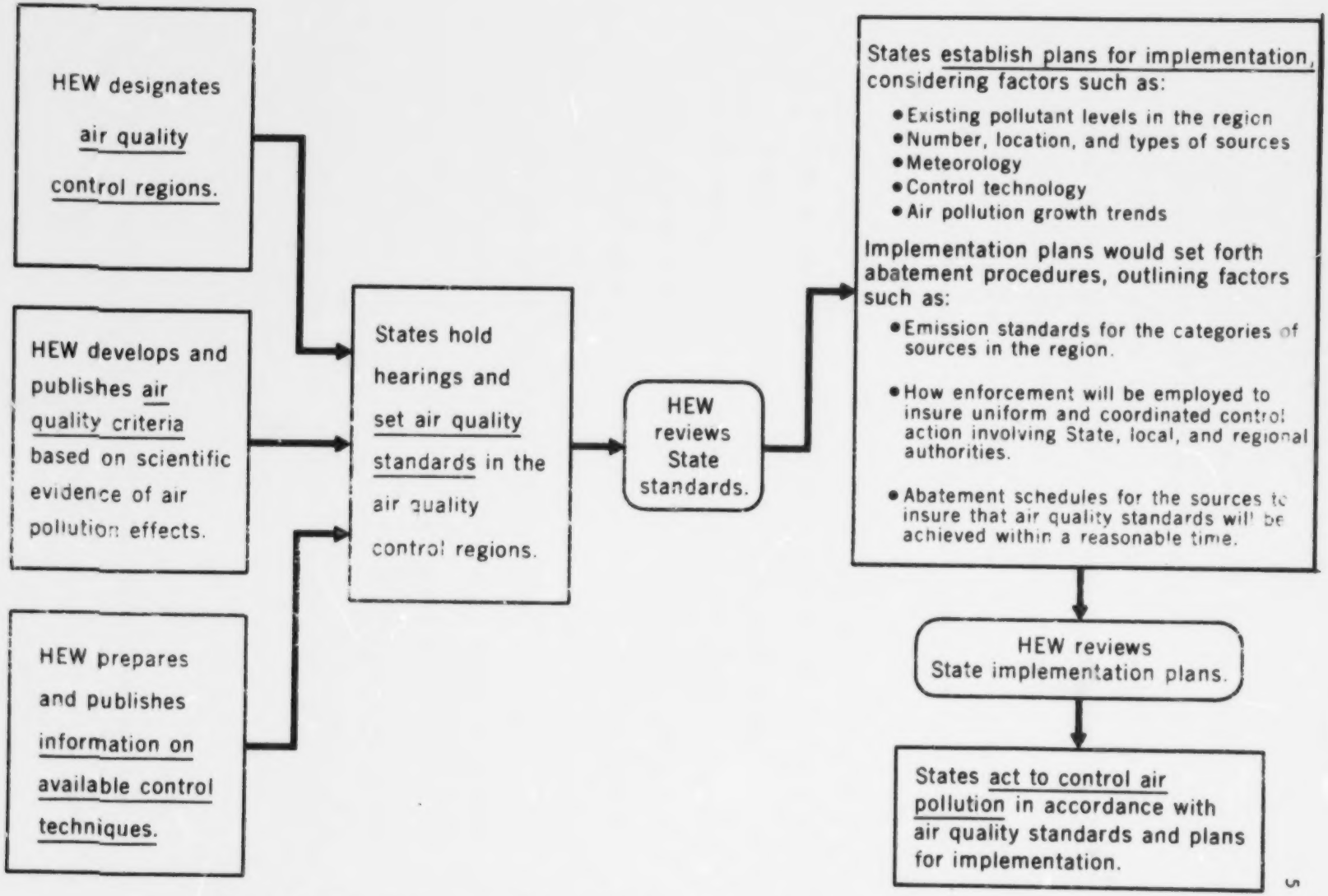

HEW designates air quality control regions.
HEW develops and publishes air quality criteria based on scientific evidence of air pollution effects.
HEW prepares and publishes information on available control techniques.
States hold hearings and set air quality standards in the air quality control regions.
HEW reviews State standards.
States establish plans for implementation, considering factors such as:
• Existing pollutant levels in the region
• Number, location, and types of sources
• Meteorology
• Control technology
• Air pollution growth trends
Implementation plans would set forth abatement procedures, outlining factors such as:
• Emission standards for the categories of sources in the region.
• How enforcement will be employed to insure uniform and coordinated control action involving State, local, and regional authorities.
• Abatement schedules for the sources to insure that air quality standards will be achieved within a reasonable time.
HEW reviews State implementation plans.
States act to control air pollution in accordance with air quality standards and plans for implementation.

Figure 1. Flow diagram for State action to control air pollution on a regional basis.

control technology and associated costs, the Governor(s) of the State(s) must file with the Secretary within 90 days a letter of intent, indicating that the State(s) will adopt within 180 days ambient air quality standards for the pollutants covered by the published criteria and control technology documents and adopt within an additional 180 days plans for the implementation, maintenance, and enforcement of those standards in the designated air quality control regions.

The new Federal legislation provides for a regional attack on air pollution and, at the same time, allows latitude in the form which regional efforts may take. While the Secretary reserves approval authority, the State(s) involved in a designated region assumes the responsibility for developing standards and an implementation plan which includes administrative procedures for abatement and control. Informal cooperative arrangements with proper safeguards may be adequate in some regions, whereas in others, more formal arrangements, such as interstate compacts, may be selected. The objective in each instance will be to provide effective mechanisms for control on a regional basis.

PROCEDURE FOR DESIGNATION OF REGIONS

Figure 2 illustrates the procedures used by the National Air Pollution Control Administration for designating air quality control regions.

A preliminary delineation of the region is developed by bringing together two essentially separate studies - the "Evaluation of

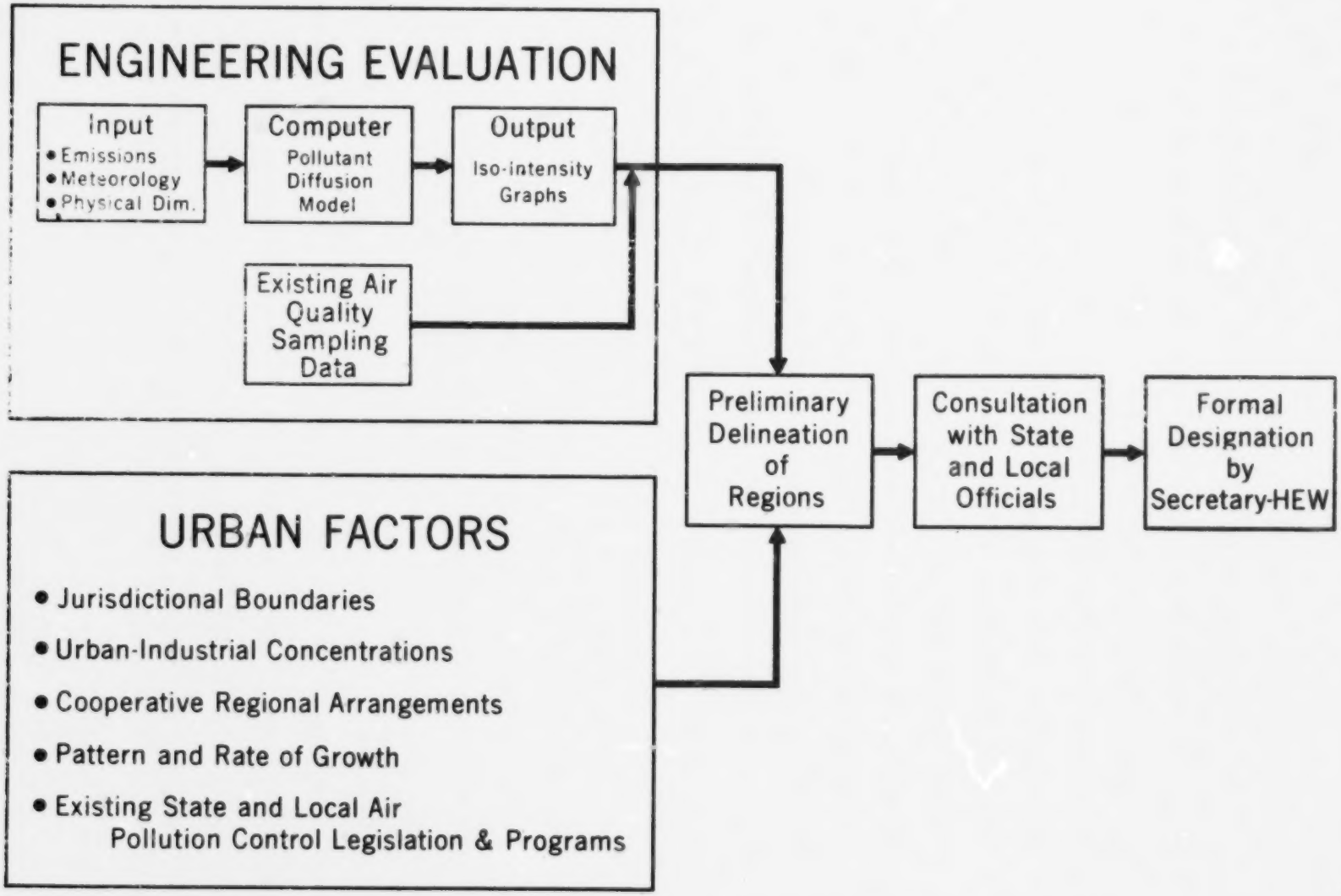


Figure 2. Flow diagram for the designation of air quality control regions.

Engineering Factors," and the "Evaluation of Urban Factors."

The study of "Engineering Factors" indicates the location of pollution sources and the geographic extent of serious pollutant concentrations in the ambient air. Pollution sources are located by an inventory of emissions from automobiles, industrial activities, space heating, waste disposal, and other pollution generators. Pollution concentrations in the ambient air are estimated from air quality sampling data and from a theoretical diffusion model. When it exists, air quality sampling data is more reliable than the theoretical diffusion model results since the data is directly recorded by pollution measuring instruments. Unfortunately, in many cases air quality sampling data is available for only one or two pollutants measured at an insufficient number of locations. The theoretical model is used to supplement inadequate air quality sampling data.

The box labeled "Input" in Figure 2 describes the information required to apply the diffusion model. This information consists of data on the type, quantity, and location of pollution emissions, the average depth of air available for mixing and dilution, the frequency of various wind velocities (direction and speed), and the physical dimensions of the urban area under study. Calculations are made with this information in the next step, labeled "Computer." The result, or "Output," of the diffusion model approach is the estimated pattern of air pollution caused by the sources of a given pollutant within the area. These patterns describe the geographic extent of air pollution in the area and serve as a

guide to the appropriate size of the air quality control region. As a whole, the engineering study indicates how large the air quality control region must be in order to encompass most pollution sources and most people and property affected by those sources.

The study of "Urban Factors" encompasses all considerations of a non-engineering nature. It reviews existing governmental jurisdictions, current air pollution control programs, present concentrations of population and industry, and expected patterns of urban growth. Other non-engineering factors are discussed when they are relevant. As a whole, the study of urban factors indicates how large an air quality control region must be in order to encompass expected growth of pollution sources in the future. It also considers which group of governmental jurisdictions will most effectively administer a strong regional air quality control program.

The conclusions of the engineering study are combined with the results of the urban factors study to form the basis of an initial proposal for an air quality control region. As shown in figure 2, the proposal is then submitted for consultation with State and local officials. After reviewing the suggestions raised during the consultation, the Secretary formally designates the region with a notice in the Federal Register and notifies the governors of the States affected by the designation.

The body of this report contains a proposal for the boundaries of the Metropolitan Chicago Interstate Air Quality Control Region and

supporting studies on engineering and urban factors. The report itself is intended to serve as the background document for the formal consultation with appropriate State and local authorities.

THE PROPOSED REGION

Subject to the scheduled consultation, the Secretary, Department of Health, Education, and Welfare, proposes to designate an air quality control region for the Chicago metropolitan area, consisting of the following jurisdictions:

In the State of Illinois

McHenry County

Lake County

Kane County

Cook County

DuPage County

Will County

In the State of Indiana

Lake County

Porter County

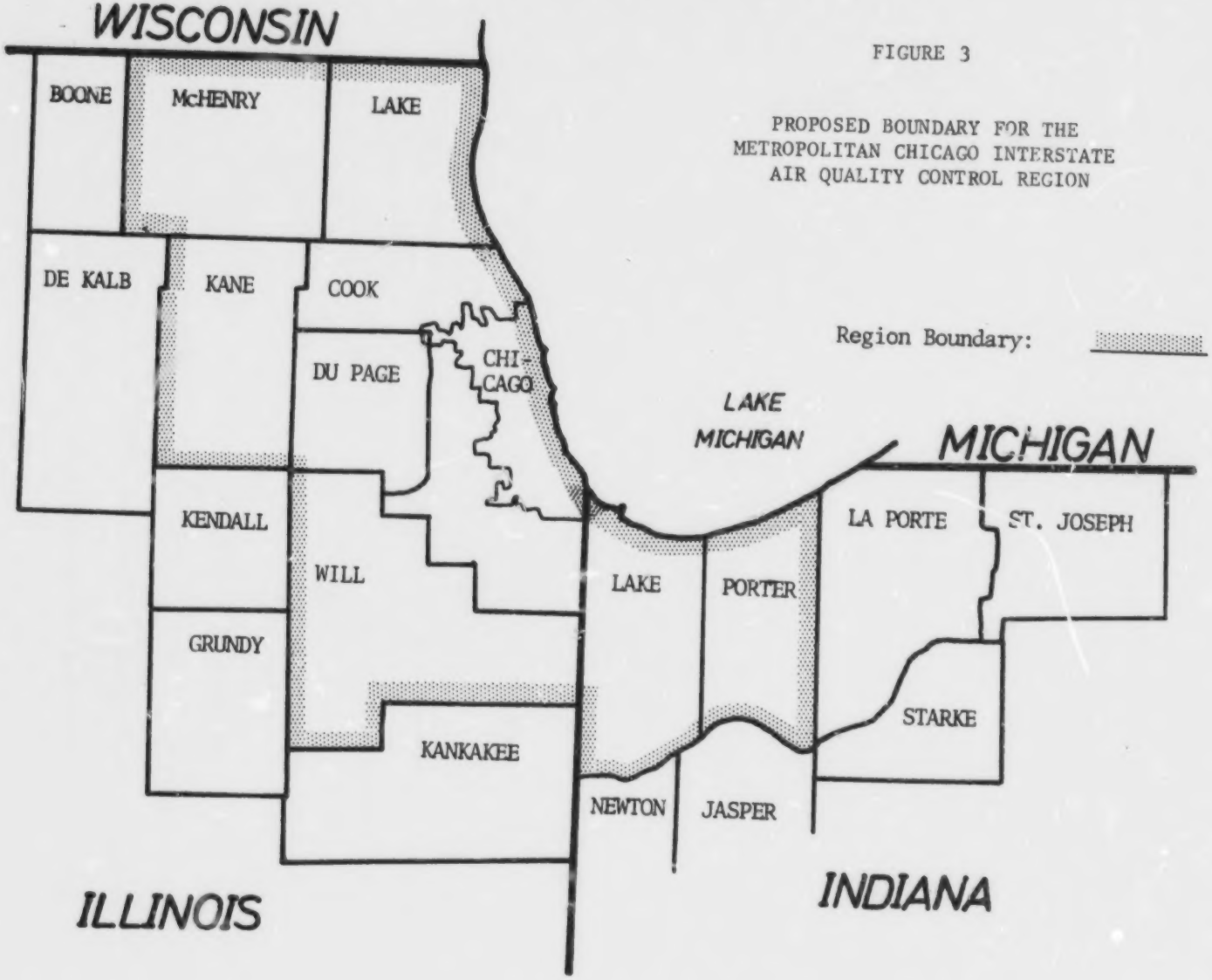
As so proposed, Metropolitan Chicago Interstate Air Quality Control Region would consist of the territorial area encompassed by the outermost boundaries of the above counties. The proposed region is illustrated in Figure 3.

DISCUSSION OF PROPOSAL

To be successful, an air quality control region should meet three basic conditions. First, its boundaries should encompass most pollution sources as well as most people and property affected by those sources. Second, the boundaries should encompass those locations where industrial

FIGURE 3

PROPOSED BOUNDARY FOR THE
METROPOLITAN CHICAGO INTERSTATE
AIR QUALITY CONTROL REGION



and residential development will create significant air pollution problems in the near future. Third, the boundaries should be chosen in a way which is compatible with and even fosters unified and cooperative governmental administration of the air resource throughout the region.

The "Evaluation of Engineering Factors" (discussion beginning with page 18) is directed toward the first of these conditions and the "Evaluation of Urban Factors" (page 33) toward the second and third.

The "Evaluation of Engineering Factors" indicates that at the present time most air pollution sources are included within the boundaries of six counties: Lake, Cook, Kane, DuPage and Will Counties in Illinois and Lake County in Indiana. Emissions from these sources directly affect the six counties. The "Evaluation of Urban Factors" indicates that the present density of population and industrial activity is high in Lake, Kane, DuPage, and Cook Counties in Illinois and Lake County in Indiana. Furthermore, except in the City of Chicago, the area included by these counties is likely to experience high rates of growth during the next twenty years. In light of these facts, it seems clear that the Metropolitan Chicago Interstate Air Quality Control Region should include at least six counties: Lake, Cook, Kane, DuPage and Will Counties in Illinois and Lake County in Indiana. These six counties form the core area of the proposed Region.

Engineering data shows that air pollution is transported in significant concentrations from the six inner core counties to five neighboring counties on the periphery of the core area; Porter, Kendall, LaPorte, McHenry, and Grundy Counties. The data also indicates that

transport of pollution affects these five outer counties to varying degrees. In the group above they appear according to decreasing degree of involvement in the Chicago air mass.

Evaluation of urban factors revealed that Porter County, the most affected county in the outer group, is also expected to experience the highest percentage rate of growth in population and industrial activity of any county in the area. In particular, the Burns Harbor Port development is expected to attract heavy industry into Porter County. Thus, it seems reasonable to include Porter County in the Air Quality Control Region, despite the fact that it is basically rural at the present time.

Kendall County, second in the outer group, is a rural county with sparse population at the present time. Furthermore, it is expected to grow at a low rate during the next twenty years. As a basis for comparison, even at the present time Porter County is nearly three times as densely populated as Kendall. By 1990, Porter is expected to be six times as densely populated as Kendall. In other words, Kendall does not contain many emission sources or people at the present time, and the situation is unlikely to change much during the next twenty years. Thus, even though engineering data indicates that Kendall is affected to some degree by air pollution from the Chicago area, it seems advisable to exclude Kendall from the Air Quality Control Region.

LaPorte County, third in importance in the outer group, had a population density slightly higher than Porter's in 1960 (157 residents per square mile compared to 142 residents per square mile). But LaPorte is expected to grow at a much slower rate (53% compared to 335%

increase over the period 1960 to 1990). Therefore, it appears unnecessary to include LaPorte County in the Air Quality Control Region for the same reason Kendall was excluded; at the present time LaPorte does not contain many emission sources or people and the situation is not likely to change much in the near future. However, there is a possibility that LaPorte County will grow at a much higher rate than expected, depending upon the impact of the Burns Harbor Port development located in neighboring Porter County. If LaPorte experiences accelerated development, it should be reconsidered sometime in the future for inclusion in the Air Quality Control Region.

McHenry County, fourth in importance in the outer group, is less densely populated than LaPorte County at the present time, but is expected to grow somewhat more quickly. If only engineering data and demographic projections are considered, it might seem unnecessary to include McHenry in the Air Quality Control Region. However, for more than a decade McHenry has been part of the planning region and has cooperated with planning efforts in the Chicago Metropolitan a[illegible]. Therefore, it seems appropriate to include it in the Region in[illegible]e to maintain and foster regional cooperation and coordination among county governments. The inclusion of McHenry County will promote the goal of unified and effective governmental administration of air pollution control in the Chicago area.

Grundy County, least affected of the counties in the outer group, is even less densely populated than Kendall at the present time and is expected to grow at an even slower pace. Thus, for the same reason that Kendall and LaPorte were excluded from the Air Quality Control

Region, it seems reasonable not to include Grundy.

In conclusion, the core area of the proposed Metropolitan Chicago Interstate Air Quality Control Region consists of six counties: Lake, Cook, Kane, DuPage and Will in Illinois, and Lake in Indiana. Porter County was included in the proposed region due to its high expected growth rate and the probable development of heavy industry within its boundaries. Kendall, LaPorte, and Grundy were excluded due to low population density at the present time and low expected growth rates. McHenry was included in recognition of existing planning regions and ongoing governmental cooperation. Counties located further from the Chicago urban center were excluded because they are not significantly affected.

As is true of most efforts to draw boundaries around an area to differentiate it from its surroundings, there is always a likelihood of boundary conditions existing or developing. In the case of Air Quality Control Regions, such a boundary condition would exist where sources of pollution on one side of the region boundary affect in some real way air quality on the other side of the boundary. Relocating the boundary would only rarely provide relief from this condition. The solution is to be found in the way in which control efforts are implemented following the designation of an Air Quality Control Region. Consonant with the basis objective of providing desirable air quality within the problem area being designated as an Air Quality Control Region, the implementation plan that follows the designation should have provisions for the control of sources located close to but beyond the region boundaries. The level of control for such sources would be a function of,

among other factors, the degree to which emissions from sources cause air quality levels to exceed the standards chosen for application within the Air Quality Control Region.

The remaining two sections of this report describe the initial evaluation of urban and engineering factors. Each is, as much as possible, independent of the other -- with respect to both subject and conclusion. As this discussion has indicated, the final proposal is based upon both studies where there was agreement among them and upon the balancing of the two where the two had differing conclusions. The Region proposed herein is considered on the whole to be the most cohesive and yet inclusive area within which an effective regional effort can be mounted to prevent and control air pollution in the two-state urban area surrounding Chicago.

EVALUATION OF ENGINEERING FACTORS

The engineering evaluation was based in part on diffusion model calculations using input data of air pollution emissions and meteorology to calculate theoretical air quality levels. These results were compared with available measured air quality data. Additional sources of information data were the "Technical Report Number 6" of the Northeastern Illinois Planning Commission[1], "Air Quality Data, State of Illinois"[2], and "Air Pollution Measurements of the National Air Sampling Network"[3-6] and local air pollution control agencies.

EMISSIONS INVENTORY

The Rapid Survey Technique[7] emission inventory, conducted by the National Air Pollution Control Administration*, developed estimates of emissions for three major pollutants--particulates, carbon monoxide, and sulfur oxides. The results, presented in Tables A-1 through A-3, Appendix A, page 64 , served as a basis for the diffusion model calculations.

The annual estimated emissions of each of the three pollutants were converted to average daily emissions and separated by source category for three different time periods--annual, winter, and summer--by apportioning according to heating-degree days those emissions which vary as a function of heating season[7]. (Table A-4, Appendix A).

Annual average emission densities, expressed in tons/day/mile^2,

*Air Quality Emissions Data Program, National Air Pollution Control Administration, Public Health Service, U. S. Department of Health, Education, and Welfare.

were determined for each of the three pollutants by relating the total quantity of pollutants emitted in each of the reporting zones to the land area of each zone. The resulting emission densities are presented graphically in Figures 4-7. Because sulfur oxide emissions change considerably during the heating season, Figure 7 was included to show sulfur oxide emissions densities for an average winter space-heating day, (December, January, and February).

The pattern of particulate, carbon monoxide, and sulfur oxide emissions show the geographic extent of the air pollution emission sources. The particulate emission densities indicate primarily the extent of industrial, heating, power and incineration sources. Figure 4 shows high particulate emission densities in the central Chicago metropolitan area, primarily the result of winter commercial space heating. The highly industrialized area of Southeast Chicago and East Chicago Northwest Gary registers high particulate emissions, primarily from steel mills, power plants, and foundries. The particulate density in the East Chicago-Northwest Gary area is substantially higher than the density in central Chicago due to heavy industrial point sources.

Carbon monoxide emission densities primarily indicate the impact of motor vehicle emissions, (Figure 5). Over 92 percent[7] of all carbon monoxide emitted in the Chicago area comes from motor vehicles, compared to 79 percent for the Gary metropolitan area. This comparison indicates that stationary sources in the Gary area are significant emitters of carbon monoxide.

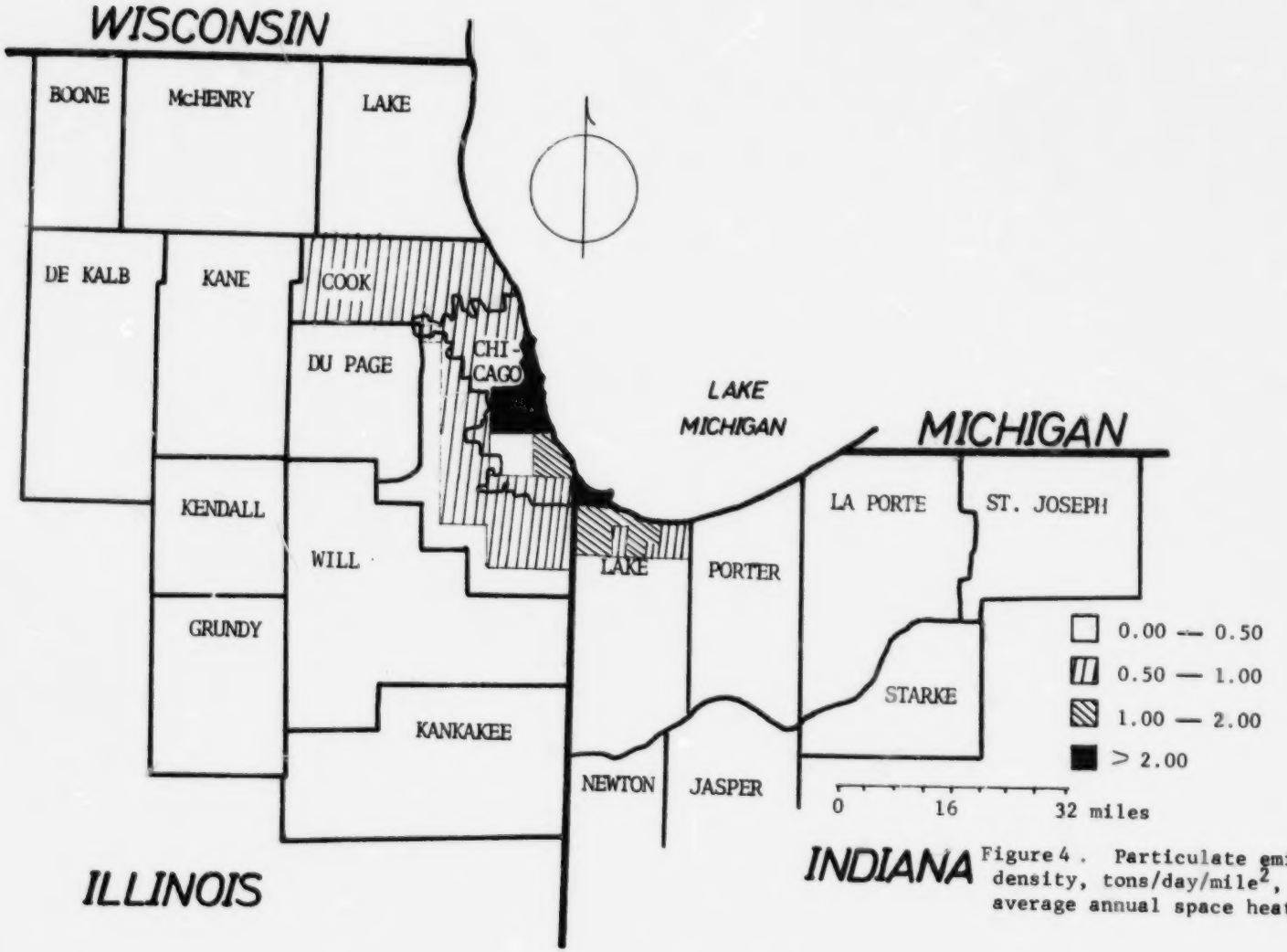


Figure 4. Particulate emission density, tons/day/mile^2, average annual space heating day.

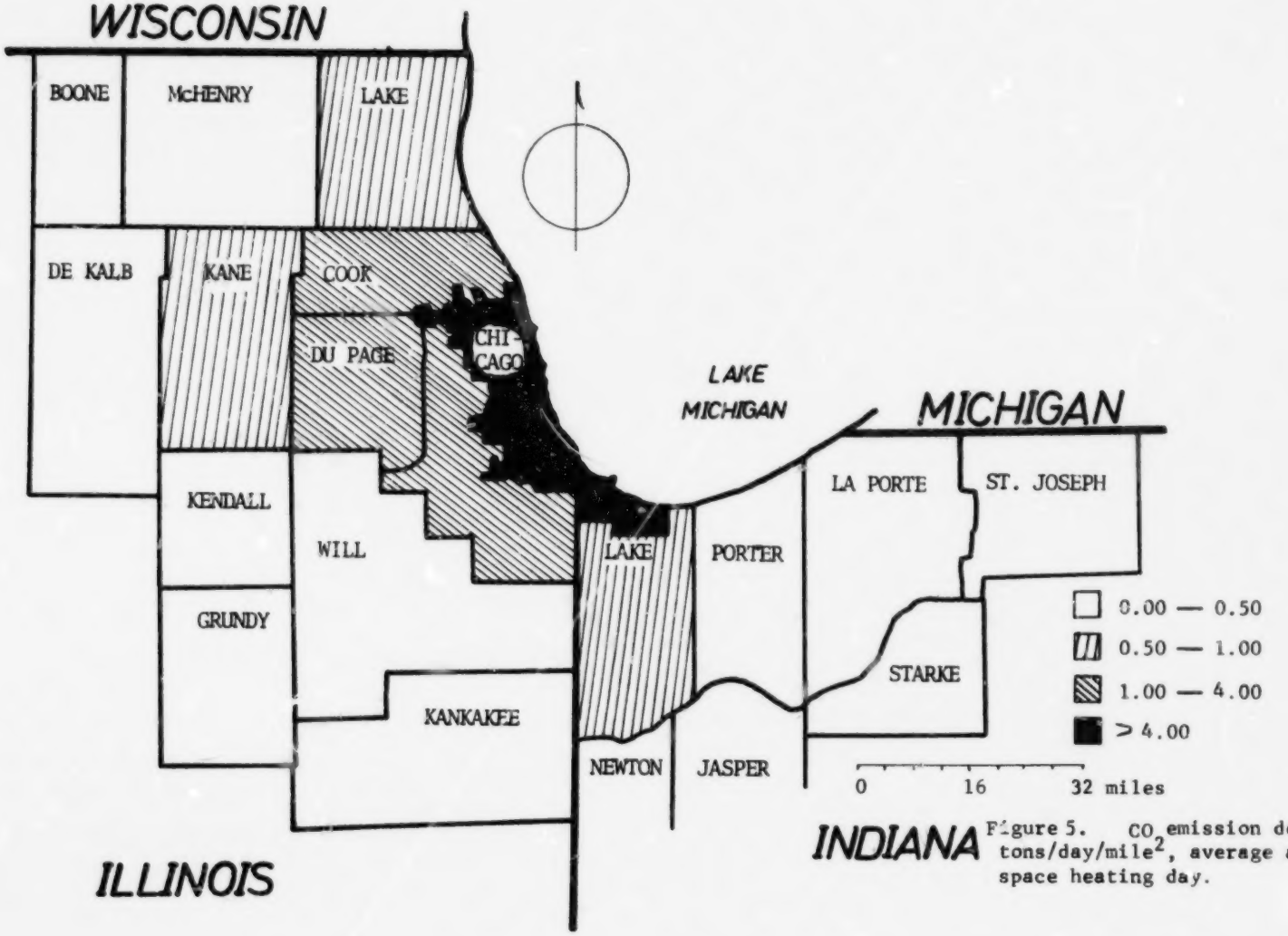


Figure 5. CO_2 emission density, tons/day/mile^2, average annual space heating day.

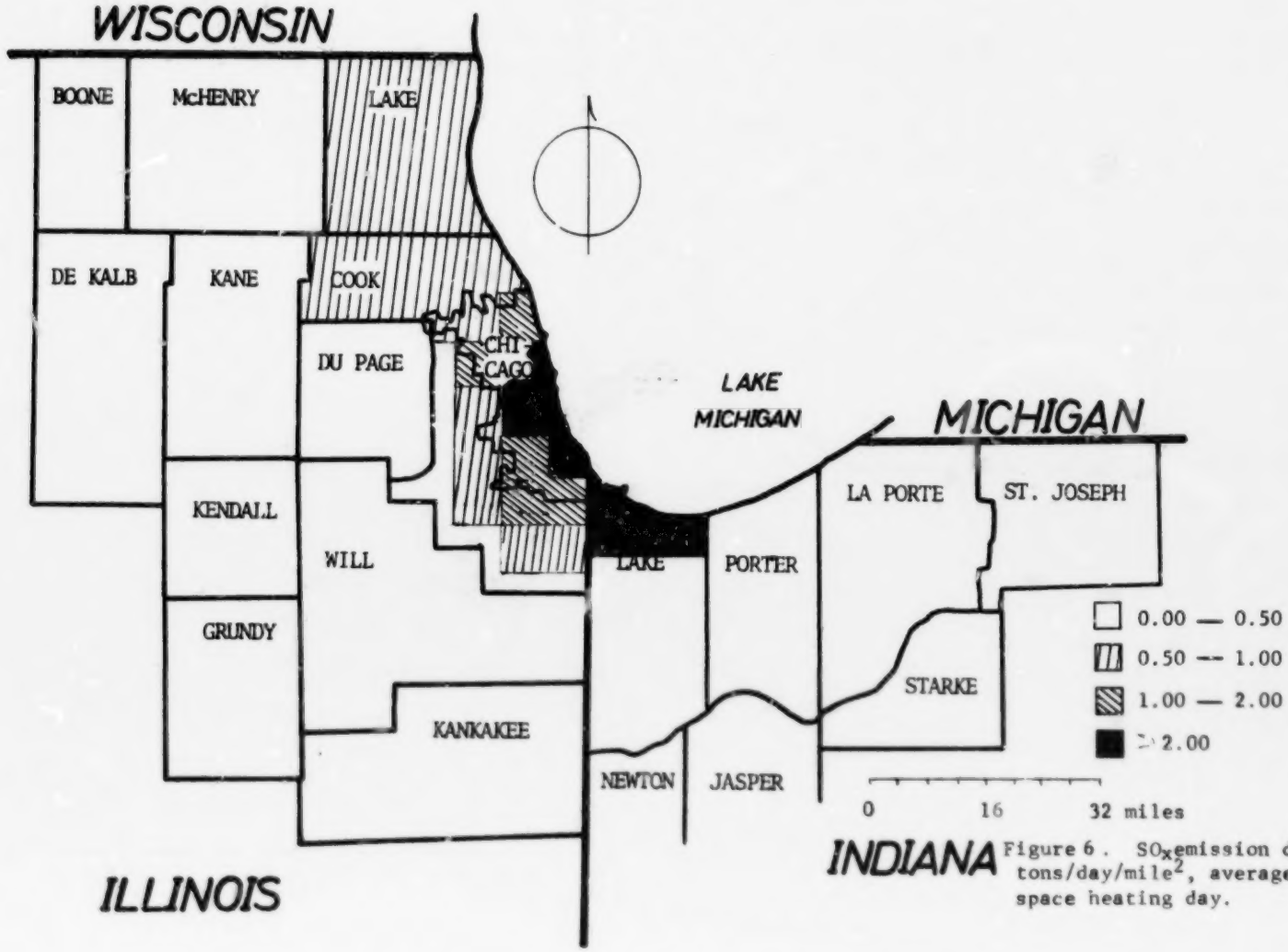


Figure 6. SO_x emission density, tons/day/mile^2, average annual space heating day.

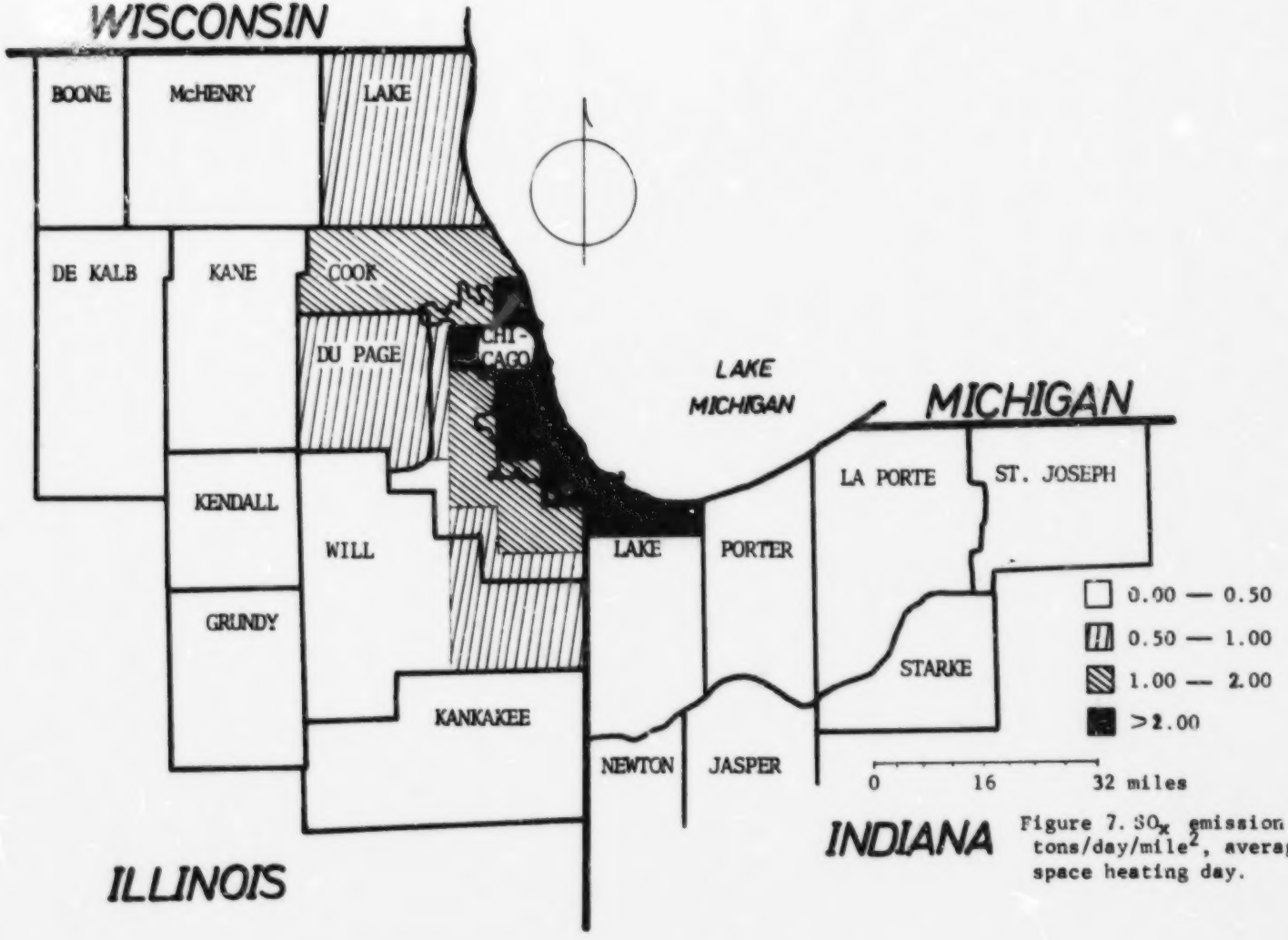


Figure 7. SO_x emission density, tons/day/mile^2, average winter space heating day.

The sulfur oxide emission densities illustrate the distribution of fuel burning activities at private, commercial, industrial, or governmental establishments and power plants. The annual sulfur oxide emission density map, Figure 6, shows high concentrations in the central metropolitan-southern industrial Chicago area. These high densities extend into the East Chicago, Hammond, and Gary metropolitan industrial area. The average winter sulfur oxide emission density map, Figure 7, shows higher densities extending into the remainder of Cook, DuPage, and eastern Will Counties. These emissions are primarily related to residential-industrial-commercial space heating.

A map showing the major point sources of particulate and sulfur dioxide emissions is shown in Figure A-1, Appendix A.

DIFFUSION MODEL RESULTS

While the geographic distribution of pollutant emissions and sources illustrate clearly the core area of the air pollution problem, it does not, by itself, provide complete insight as to the extent of influence of the combined sources on the people and property located outside the highly urbanized portion of the Chicago-Gary metropolitan areas.

Thus, a study of air quality levels, measured or estimated, is useful in determining which areas are affected by the pollution sources, and thus are candidates for inclusion in the air quality region. Such analysis can be based directly on air quality sampling data in those instances where the sampling program covers a large enough area, i.e. extending near proposed regional boundaries under study. Such air

quality data, measured over a time period long enough to provide a reliable pattern, rarely exists. It becomes necessary then to estimate prevailing air quality through use of the diffusion model technique.[8,9,10]

A description of the diffusion model used in this study, the meteorological data input, the diffusion model results, and measured air quality levels are shown in detail in Appendix B. The diffusion model results concerning the metropolitan Chicago Interstate Air Quality Control Region are discussed below.

By estimating the patterns of dispersion of the three major pollutants, SO_2, particulates, and carbon monoxide, the diffusion model technique provides a guide as to a possible minimum boundary for the region but does not dictate the exact boundary location. By way of example, if significant concentrations of one or more of the three pollutants in a county contiguous to a major urbanized area, is a result or carryover from the core area, this would indicate the county is involved in an area-wide problem. This county, then, should be considered for inclusion in the air quality control region, especially when the county also contributes to the air pollution in the core area. The final decision, however, should be based on joint consideration of non-engineering as well as engineering factors.

Particulates

The diffusion model estimates of theoretical particulate concentrations may be less than ideal for two reasons: 1) they do not include an allowance for background concentrations; and, 2) they are based on an emission inventory that estimates total particulate

emissions, and therefore, do not account for deposition of the larger particles. The first would cause the model estimate to be lower than measured concentrations, and the second would cause the estimate to be higher than measured concentrations of suspended particulates; however, theoretical results compare quite well with measured air quality data.

Theoretical results for suspended particulate levels show only minor variation from a seasonal standpoint, (Figures B-2 through B-4, Appendix B). Comparing the annual theoretical suspended particulate values, Figure 8, with annual measured suspended particulate values, Figure B-5, Appendix B, good agreement exists on the 100 $\mu g/m^3$ contour line except where the measured 100 $\mu g/m^3$ isoline extends further west into Will, Kendall, and Kane Counties. This difference is probably due to the influence of some major point sources in central Will County, shown in Figure A-1, Appendix A.

The diffusion model results tend to over-estimate suspended particulate values inside the 100 $\mu g/m^3$ contour line and under-estimate values outside this contour line. Because of this discrepancy between theoretical and observed values it is difficult to assign a constant which adjusts theoretical to observed values. Available data shows the 75 $\mu g/m^3$ measured suspended particulate level to be the limit for the area most affected by particulate emissions in the Chicago-Gary metropolitan area. The 40 $\mu g/m^3$ theoretical isoline corresponds graphically to this measured level. Using these two related levels as guidelines for determining boundaries the following counties are affected on a summer, winter, or annual basis: Lake, Cook, Will, McHenry, Kane, DuPage, Kendall, and Grundy, in Illinois; and Lake, Porter, and LaPorte, in Indiana.

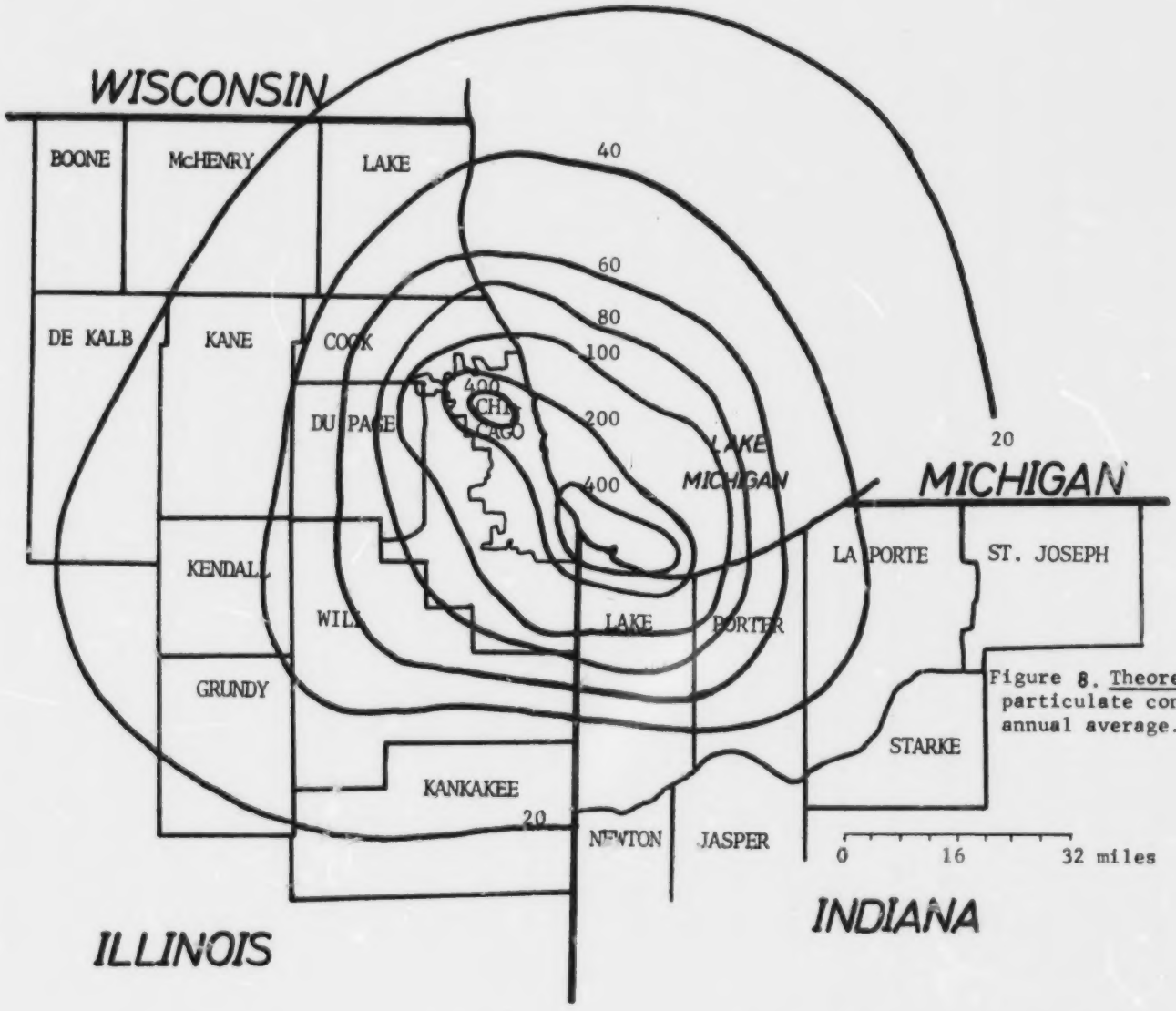


Figure 8. Theoretical particulate concentration--$\mu g/m^3$, annual average.

Carbon Monoxide

The results of the theoretical diffusion model estimates for carbon monoxide concentrations during the three seasonal conditions are presented in Figures B-6 through B-9 in Appendix B, page 78 . For the purpose of showing the relative distribution of CO levels, the model estimates are adequate, but to draw any conclusions on regional boundaries based on theoretical carbon monoxide levels a conversion factor must be applied to the theoretical diffusion model results. The diffusion model results tend to be lower than measured carbon monoxide levels, since the diffusion model does not reflect the built-up nature of the urban area in which most of the CO is emitted and measured. The model assumes that the pollutant has more immediate space to disperse than is the actual case. In addition, CO measurements are made at selected locations near busy streets. In the previous two Regions, Washington, D. C., and New Jersey-New York-Connecticut, factors, 3.5 and 4.5 respectively, were applied to the theoretical results to bring measured and theoretical results into agreement. These factors were arrived at by comparing the theoretical values with measured results. Taking the above information into consideration, and comparing the theoretical and measured results in the metropolitan Chicago area, a factor of 5 was derived and then applied to the average summer day theoretical diffusion model results to give "adjusted" CO concentrations, (Figure 9). Theoretical diffusion model results for an average summer day were chosen because this gave the highest theoretical results among the three seasons considered, and consequently affecting the largest area.

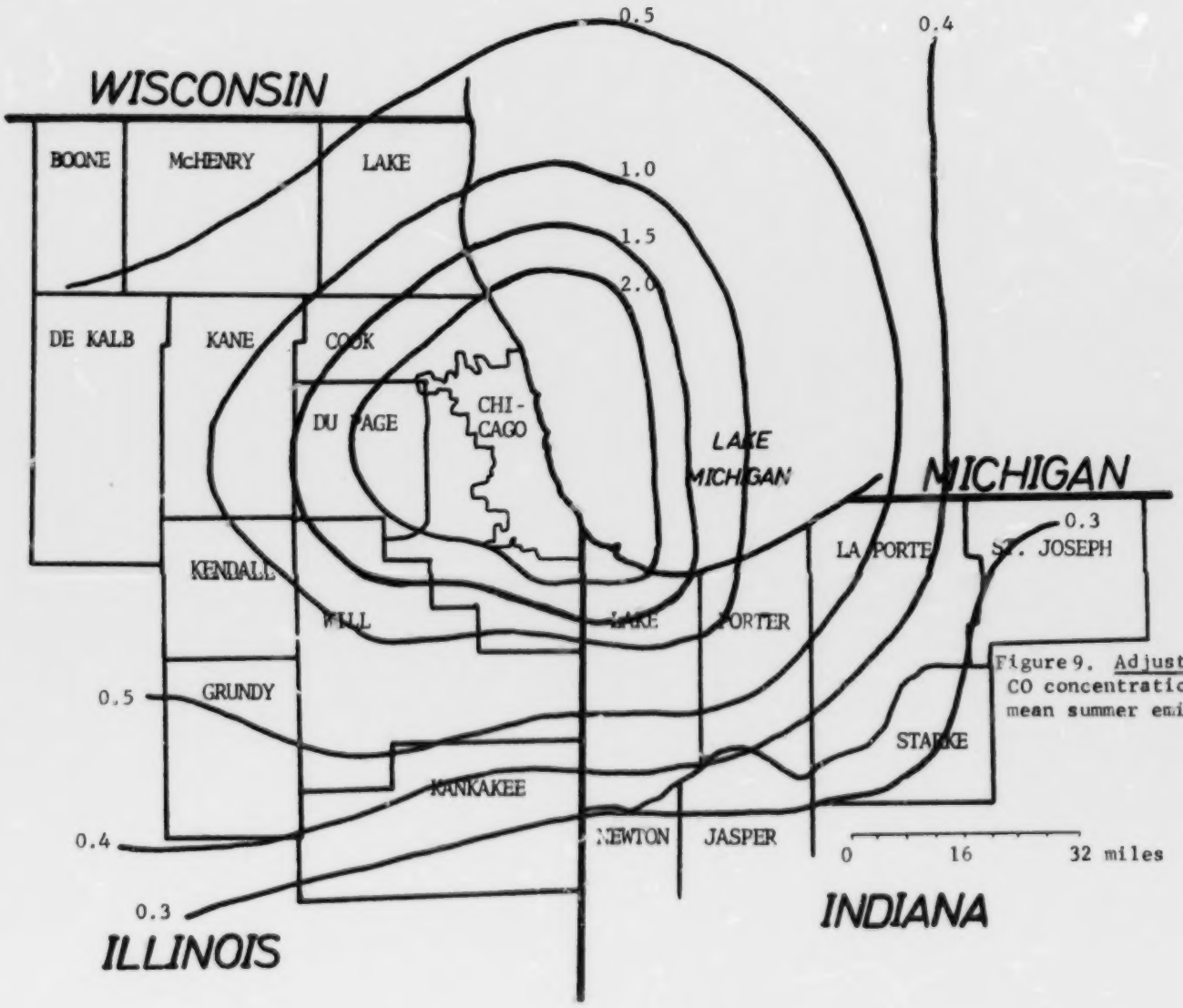


Figure 9. Adjusted Theoretical CO concentration--ppm, based on mean summer emission levels.

Using the CO contour line of one ppm* for an average summer day as a guide to the region boundary, the following counties are affected: Lake, Cook, Will, McHenry, Kane, DuPage, and Kendall in Illinois; and Lake and Porter in Indiana.

Sulfur Oxides

The results of the theoretical diffusion model estimates for sulfur oxides for mean annual, summer, and winter conditions are presented in Figures B-9 through B-11 in Appendix B. A 3-hour half-life, (to allow for the atmospheric reaction of SO_x into other sulfur compounds), was applied to the initial output of the model because it gave the best correlation with sampling data, (Figure B-13).

The 0.01 ppm SO_x contour line for the 3-hour half-life diffusion model results is considered an appropriate level for determining regional boundaries. The 0.01 ppm SO_x level has been pointed out as the average annual concentration at which human health begins to show signs of deterioration. It is also assumed that this level is close to the background level in highly urbanized areas. This 0.01 contour line, for a mean annual condition (Figure 10) extends through, or encompasses the following counties: Lake, Cook, Will, McHenry, Kane, DuPage, Kendall, and Grundy in Illinois; and Lake and Porter in Indiana. This contour line also extends into LaPorte County, Indiana for a mean summer condition.

*1 ppm of CO is assumed to be close to the background level in most highly urbanized areas; this value at the outskirts of an area, then might be used as a starting point in defining the area affected by sources within the region.

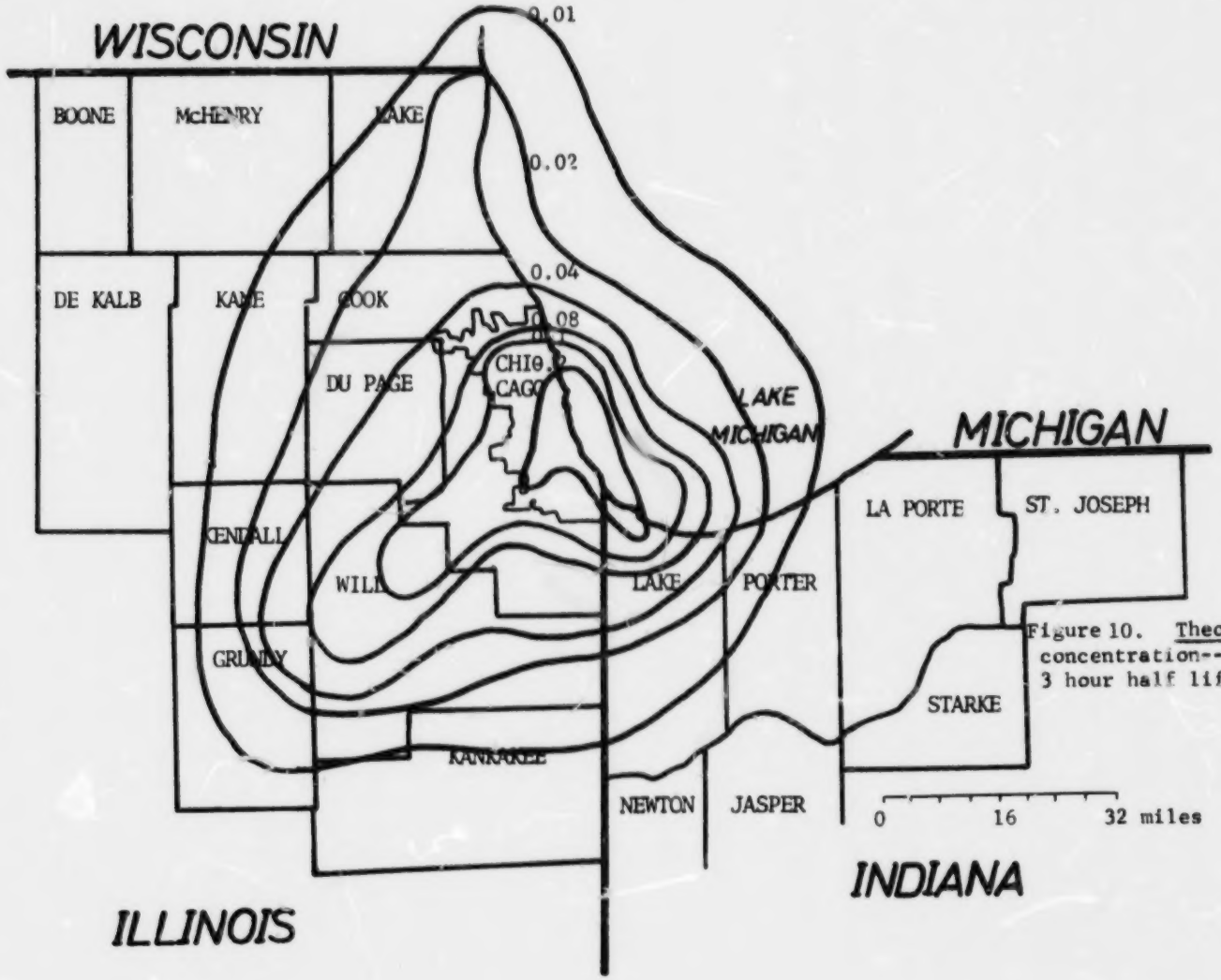


Figure 10. Theoretical SO_x concentration--ppm, mean annual, 3 hour half life.

SUMMARY OF ENGINEERING EVALUATION

Particulates:

The 75 $\mu g/m^3$ contour line extends near, through, or encompasses eight Illinois Counties (Lake, Cook, Will, McHenry, Kane, DuPage, Kendall, and Grundy); and three counties in Indiana (Lake, Porter, and LaPorte).

Carbon Monoxide:

The 1 ppm contour line encompasses or extends near, through, or encompasses seven Illinois counties (Lake, Cook, Will, McHenry, Kane, DuPage, and Kendall) and two counties in Indiana (Lake and Porter).

Sulfur Oxides:

The 0.01 ppm countour line extends near, through or encompasses eight Illinois counties (Lake, Cook, Will, McHenry, Kane, DuPage, Kendall, and Grundy) and three Indiana counties (Lake, Porter, and LaPorte).

Conclusion.

Through the use of a diffusion model one can estimate the concentration of air pollutants at various locations. Thus, if there is any indication that the above pollutant levels exist in counties surrounding the Metropolitan Chicago urban areas on a summer, winter, or annual basis, those counties should be considered for inclusion in the air quality control Region. The engineering evaluation indicates that eight counties in Illinois (Lake, Cook, Will, McHenry, Kane, DuPage, Kendall, and Grundy) and three counties in Indiana (Lake, Porter, and LaPorte) should be considered for inclusion in the Region.

URBAN FACTORS

The second condition for air quality control region boundaries requires that they encompass anticipated future development of industrial and residential land. Projections for industrial and residential development in the Chicago-Gary metropolitan area demonstrate that most of the growth which is likely to occur during the next ten to fifteen years will be located in an eight county area surrounding Chicago and Gary.

Figure 11 shows population density in the Chicago-Gary area by county according to the 1960 census. Figure 12 registers the expected absolute population growth (number of additional residents per square mile from 1960 to 1990) by county. Figure 13 shows the expected population density in 1990, by county. See note 1 for an explanation of the sources of population projections,page 58.

The statistics presented in these figures are only approximations but are indicative of present and expected future changes in density of population. They show that the City of Chicago, which is already populated densely, will probably register little or no growth during the next twenty years. On the other hand, absolute population growth will be very high in the suburbs immediately surrounding the City of Chicago. DuPage and suburban portions of Cook County will have approximately ,000 more residents per square mile in 1990 than they did in 1960. Porter and Lake Counties in Indiana and Kane and Lake Counties in Illinois will also experience large absolute increases in population; approximately 500 additional residents per square mile by 1990. Although

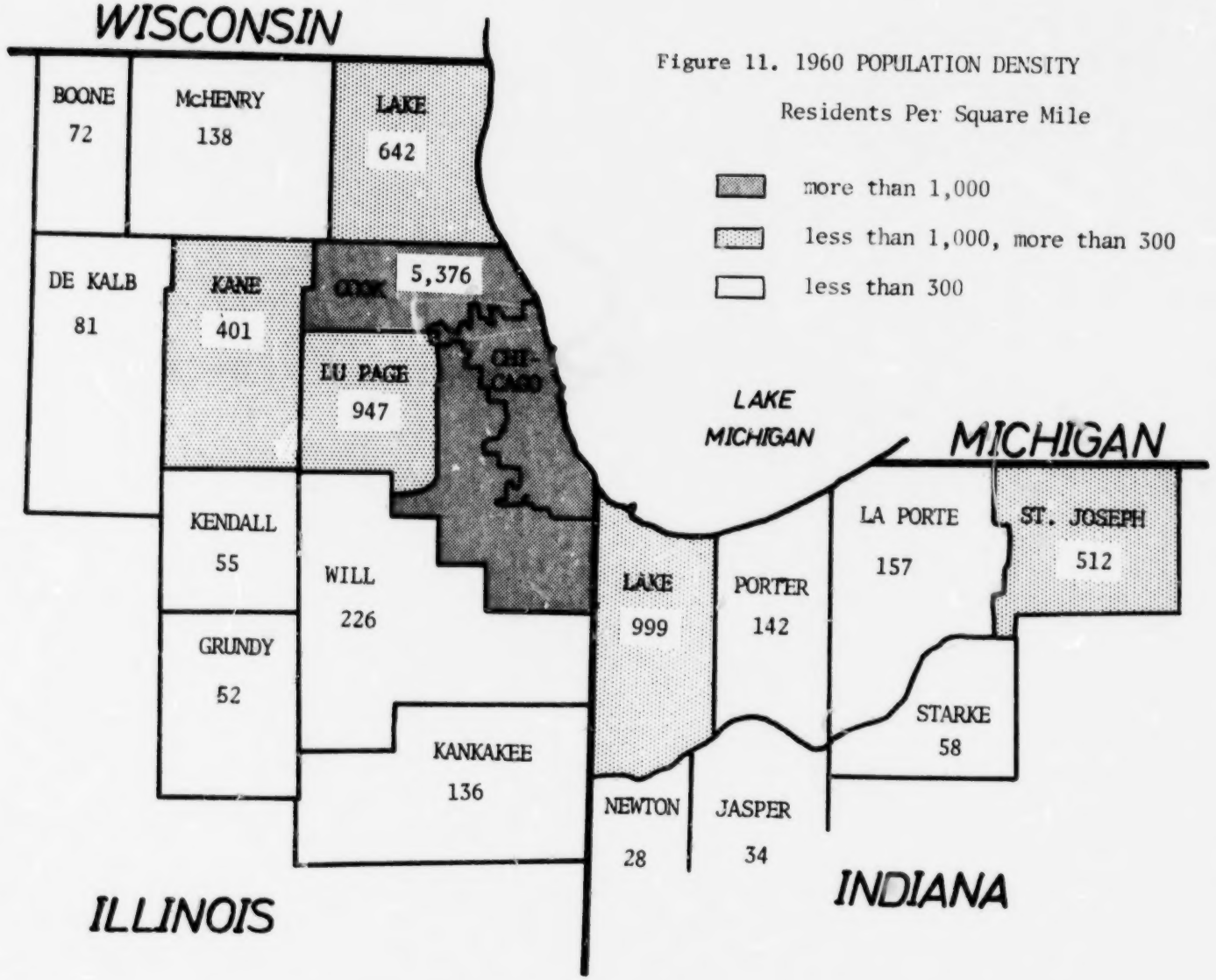


Figure 11. 1960 POPULATION DENSITY

Residents Per Square Mile

- more than 1,000
- less than 1,000, more than 300
- less than 300

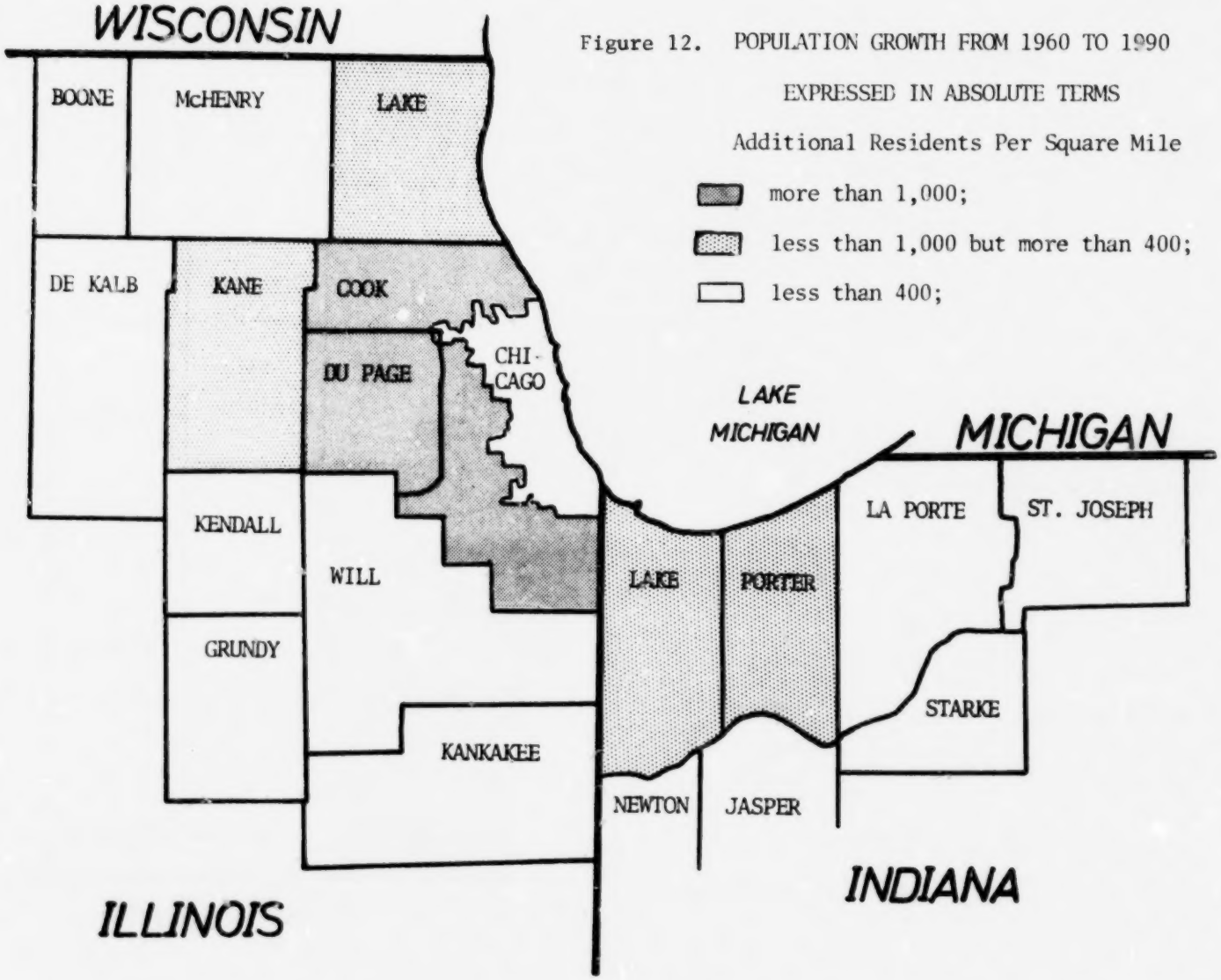


Figure 12. POPULATION GROWTH FROM 1960 TO 1990

EXPRESSED IN ABSOLUTE TERMS

Additional Residents Per Square Mile

more than 1,000;

less than 1,000 but more than 400;

less than 400;

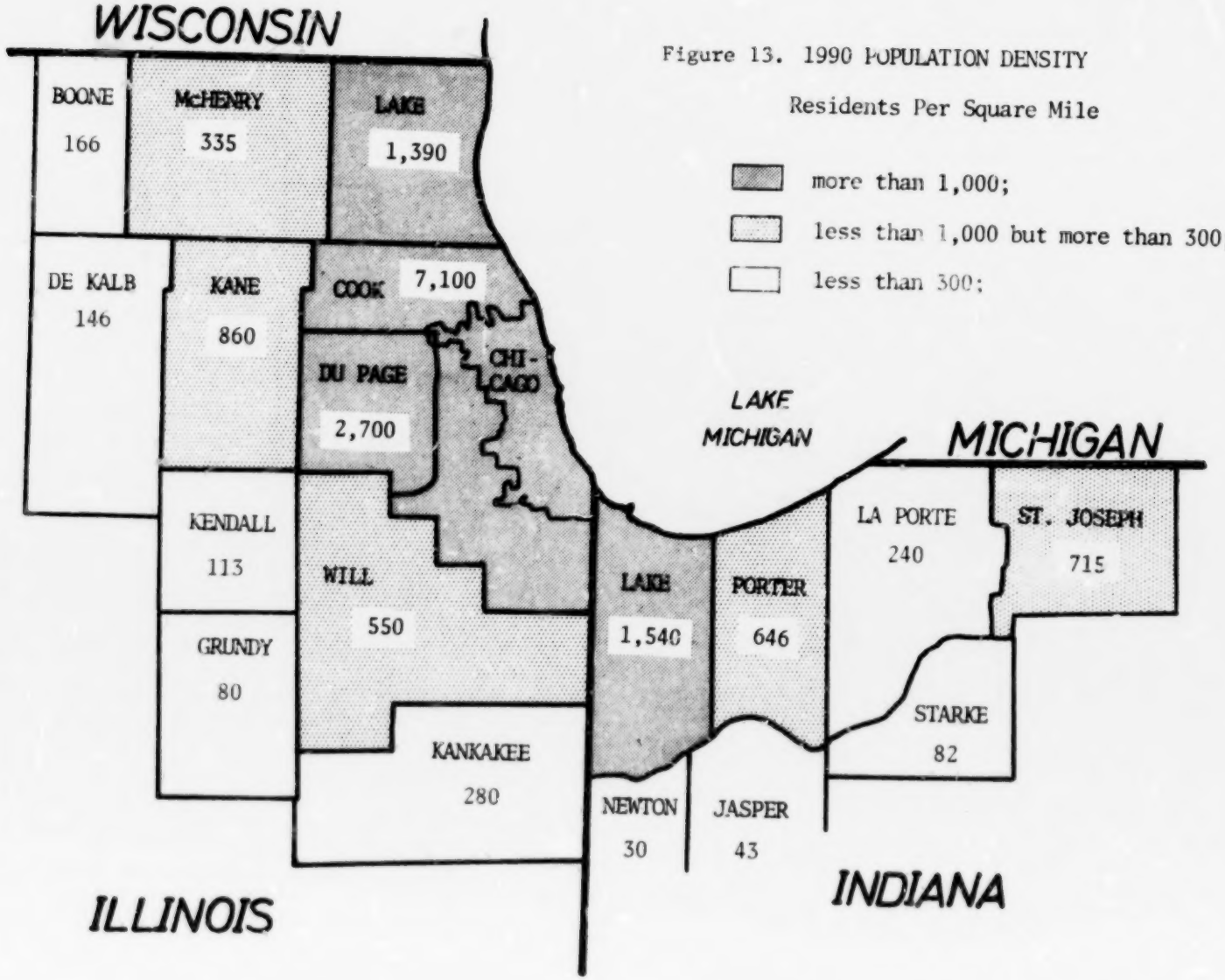


Figure 13. 1990 POPULATION DENSITY

Residents Per Square Mile

- more than 1,000;
- less than 1,000 but more than 300;
- less than 300;

the absolute growth of McHenry and Will Counties is likely to be less than the absolute growth of the more densely populated counties just mentioned, population growth expressed in percentage terms for Will and McHenry will be very high. It is expected to average about 35% per decade, which will be higher than the percentage growth rate of Kane, Lake, and suburban Cook areas.

Thus, by 1990 the City of Chicago will still have about 16,000 residents per square mile as it does today. Suburban areas of Cook County are expected to have a population density greater than 4,000 residents per square mile, while DuPage County is expected to surpass the 1960 population density of suburban areas in Cook County with 2,700 residents per square mile. Lake County, Illinois, and Lake County, Indiana, are expected to approach the 1960 population density of suburban Cook County, while Kane, Will, and Porter Counties will attain densities comparable to the 1960 population level in Lake County, Illinois. All of these areas will have 550 or more residents per square mile by 1990. The expected growth pattern will tend to erase the population density difference between the cities of Chicago and Gary relative to the surrounding areas. Thus, during the next twenty years, most of the population growth in the Chicago-Gary area will take place in seven counties; Lake, Kane, Cook, DuPage and Will Counties in Illinois and Lake and Porter Counties in Indiana. None of the counties in Illinois and Indiana surrounding these seven counties is likely to even approach significant population growth, with the possible exception of McHenry.

Since human activity is the ultimate cause of air pollution,

population growth statistics often indicate the location of growing air pollution emissions. For example, growth of emissions from residential space heating are closely related to population growth. Figures 14 and 15 illustrate this by showing the percent of land in residential use in 1960 and the expected increase in residential land use to 1995. These statistics indicate that growth in residential land use will parallel the expected growth in population; the bulk of the growth will occur in the suburban areas surrounding Chicago and Gary. Residential land use, in turn, is directly related to space heating emissions. As another example, population growth in suburban areas signals the probable increase of emissions from automobiles. Figure 16 indicates the density of automobile registrations in 1966 by county. Automobile registrations in future years will undoubtedly rise with population growth in the suburbs.

The general conclusion to be drawn from these statistics is that the major portion of population growth, and the accompanying growth of certain air pollution emission sources, will be located within seven counties surrounding Chicago and Gary.

Expected industrial development is another indicator of where air pollution emissions are likely to increase. Figure 17 shows the present location of industrial activity in McHenry, Lake, Kane, DuPage, Cook, Will, Lake, and Porter Counties. Figure 18 shows the manufacturing employment density for 1965 in six northeast Illinois counties, based on the location of the manufacturing plant. Figure 19 indicates 1960 manufacturing employment density for the whole Chicago-Gary metropolitan area based on the location of the employee's residence. These figures indicate the general pattern of existing industrial activity. It is

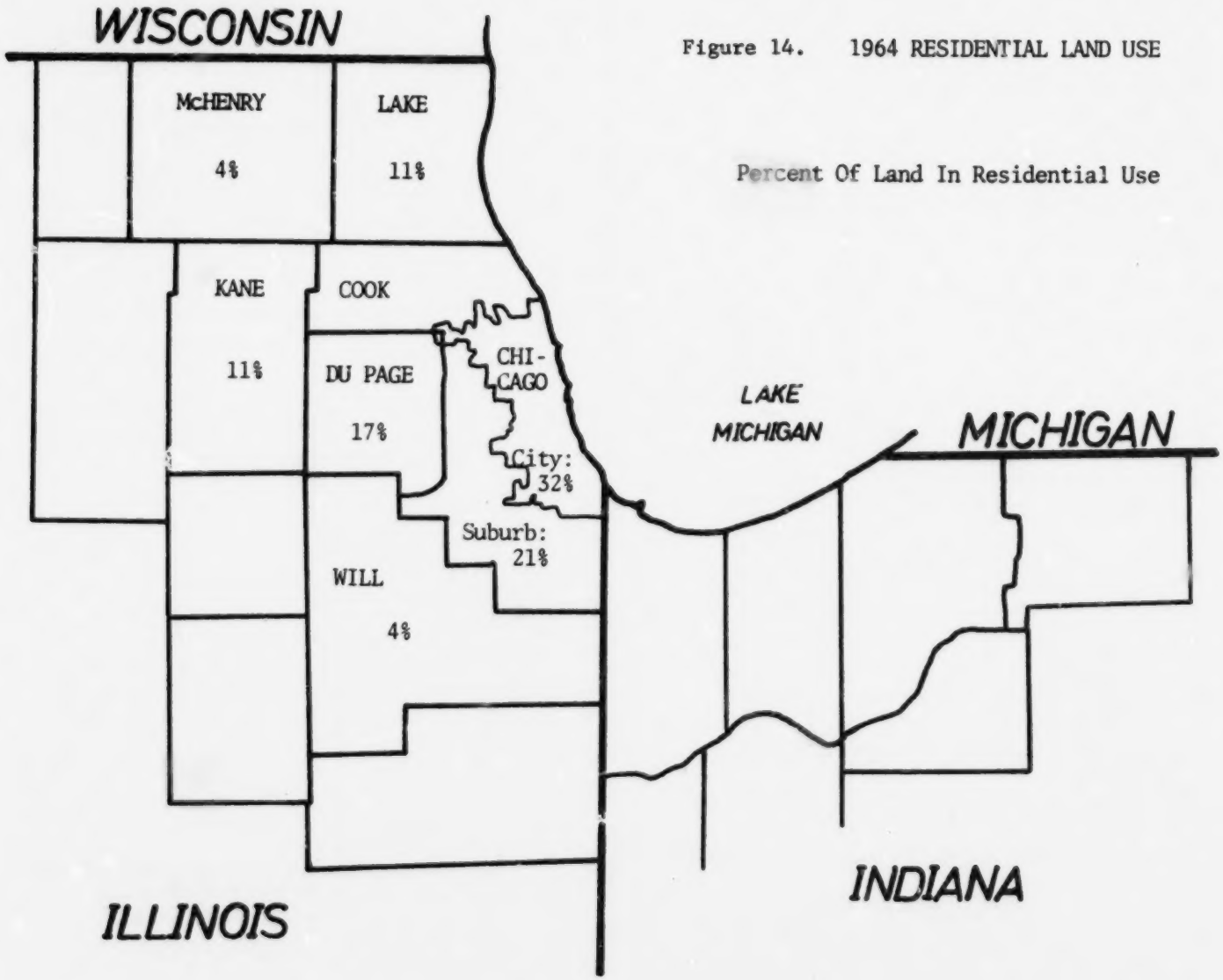


Figure 14. 1964 RESIDENTIAL LAND USE

Percent Of Land In Residential Use

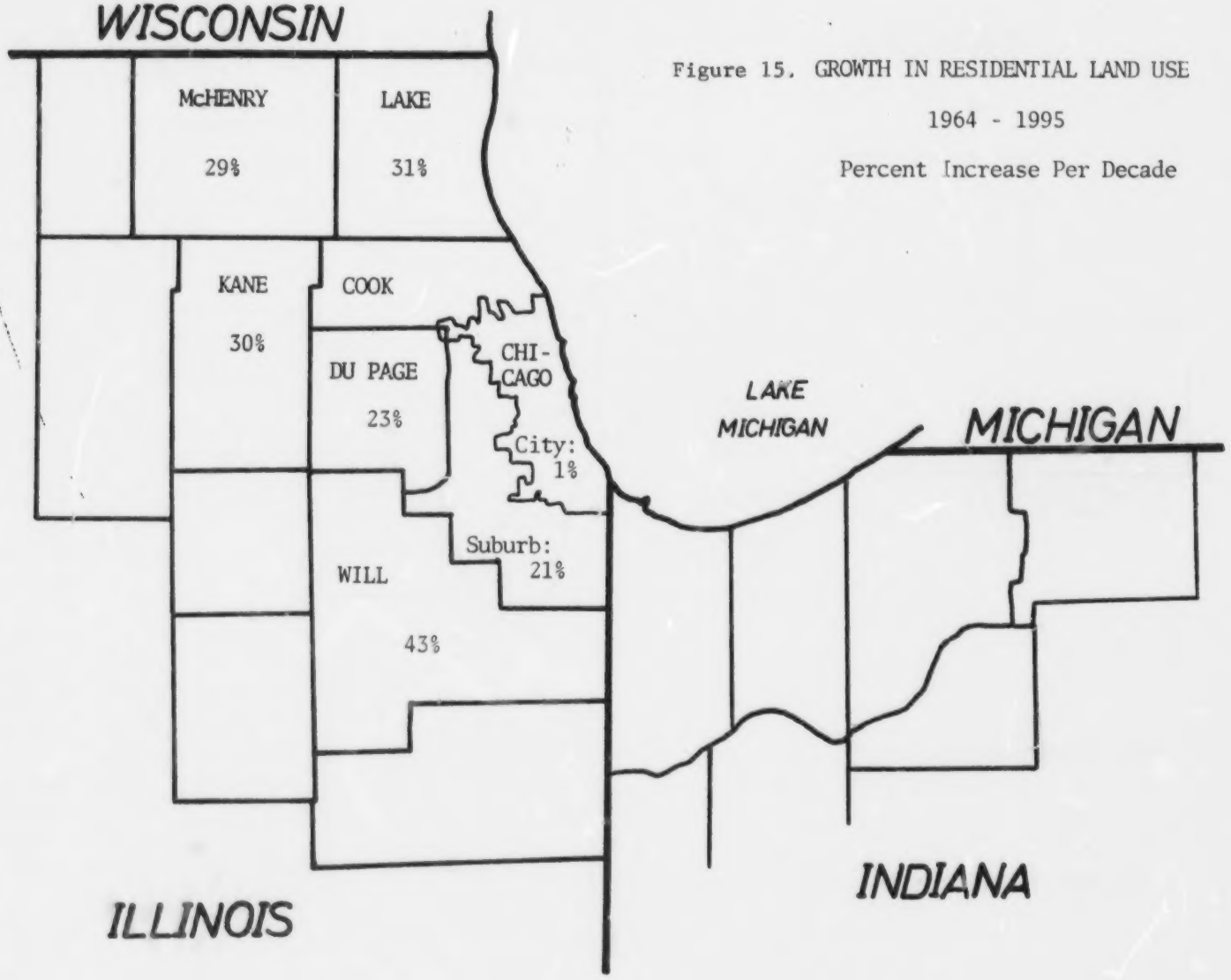


Figure 15. GROWTH IN RESIDENTIAL LAND USE

1964 - 1995

Percent Increase Per Decade

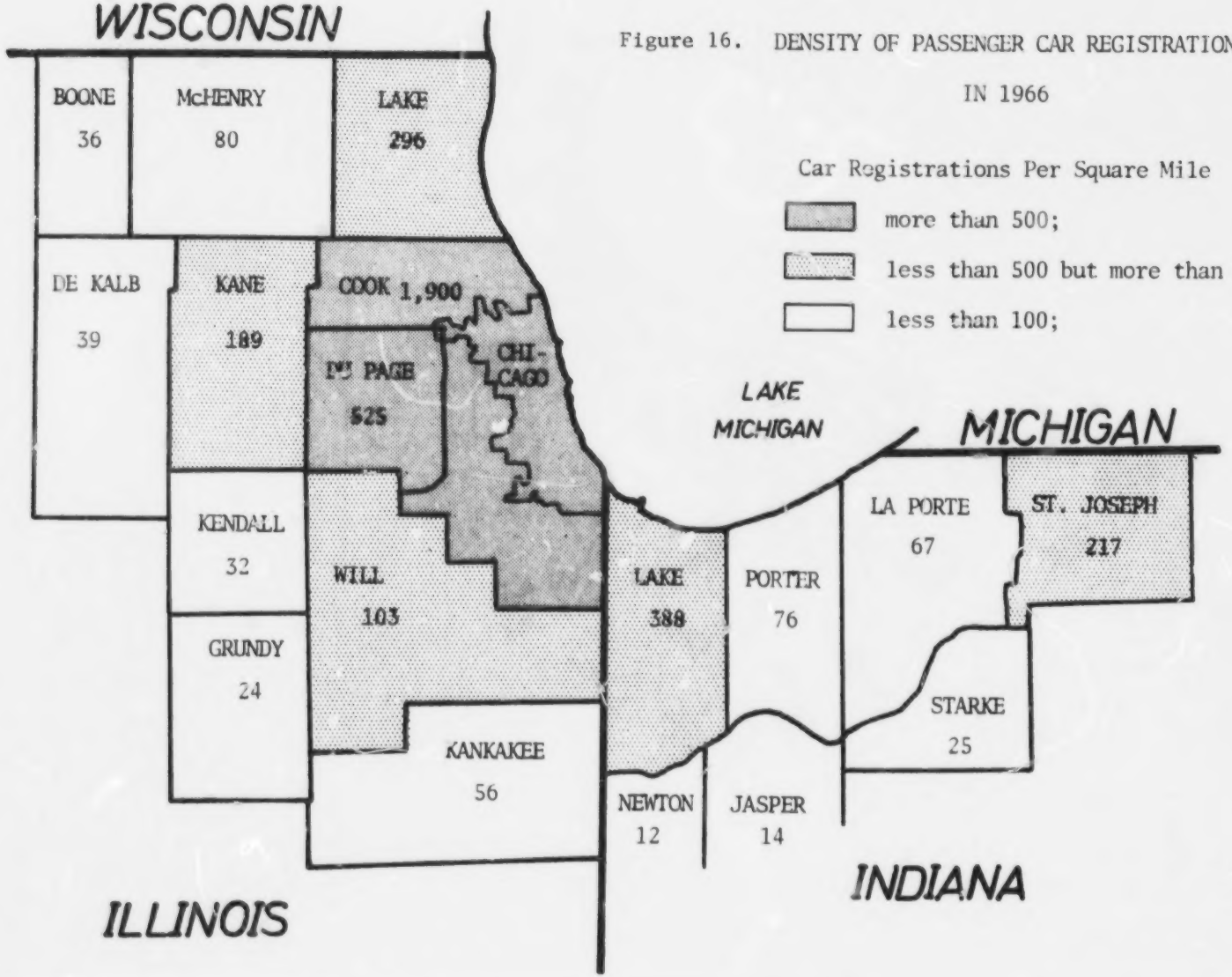


Figure 16. DENSITY OF PASSENGER CAR REGISTRATIONS IN 1966

Car Registrations Per Square Mile

- more than 500;
- less than 500 but more than 100;
- less than 100;

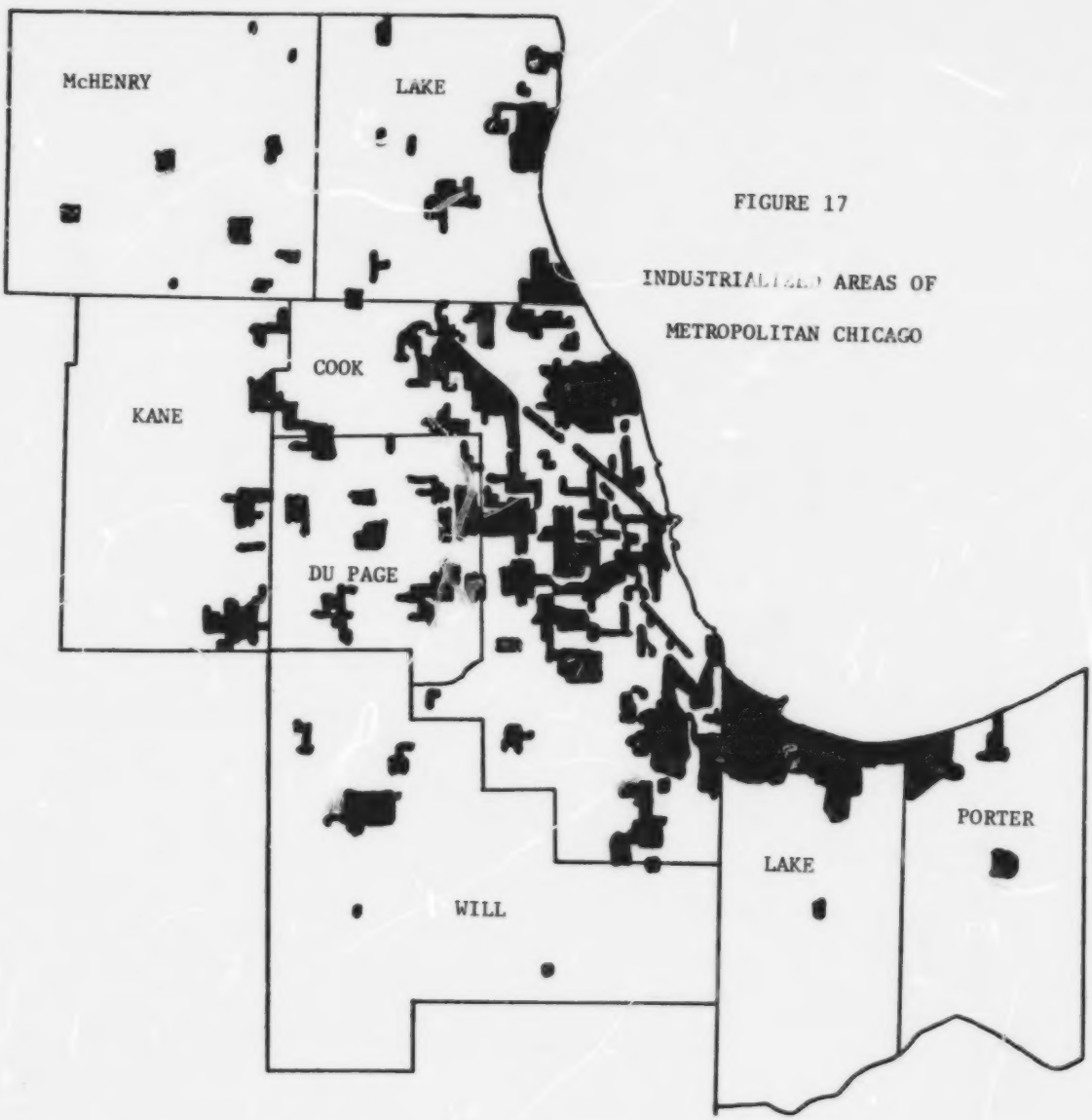


FIGURE 17

INDUSTRIALIZED AREAS OF

METROPOLITAN CHICAGO

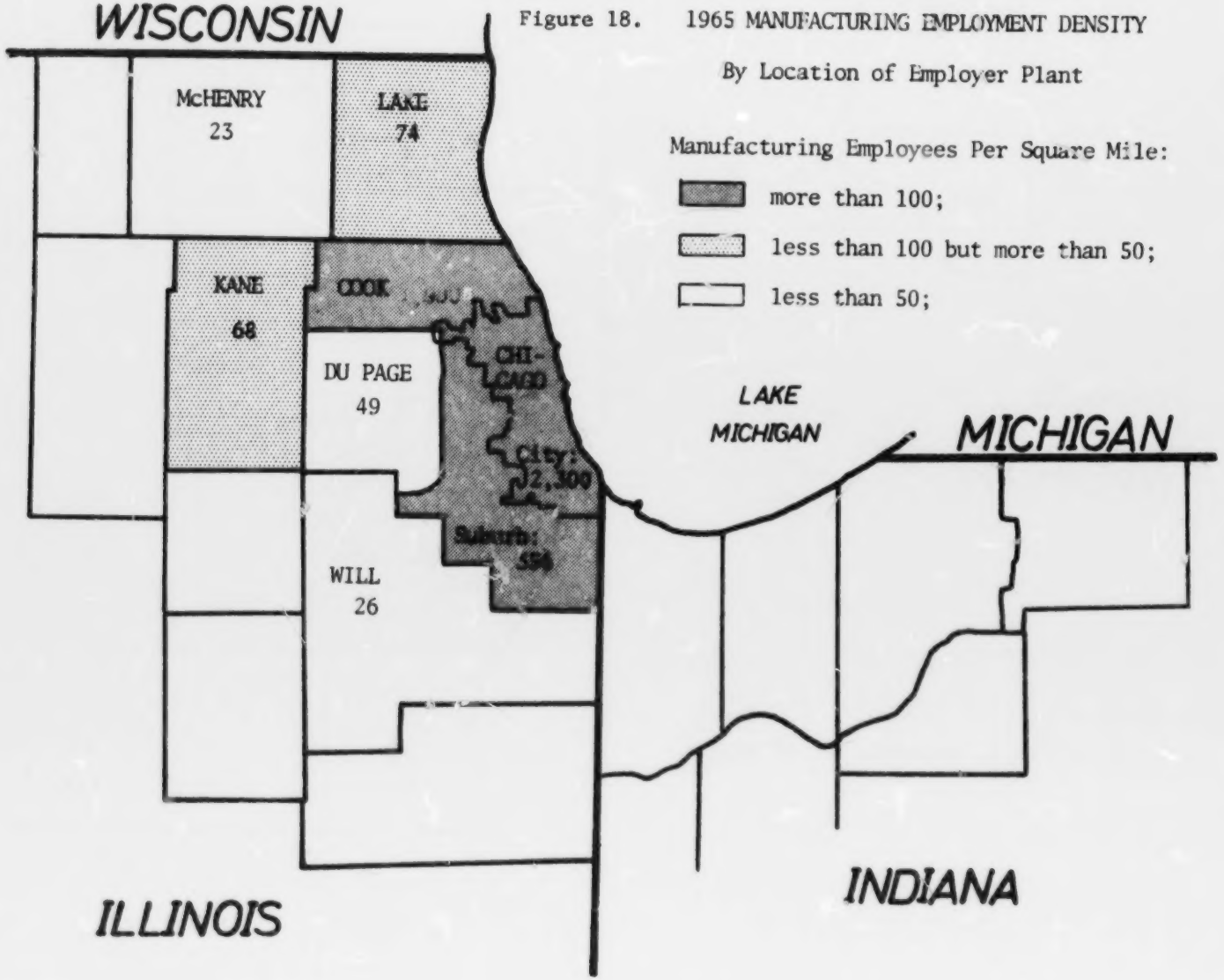


Figure 18. 1965 MANUFACTURING EMPLOYMENT DENSITY

By Location of Employer Plant

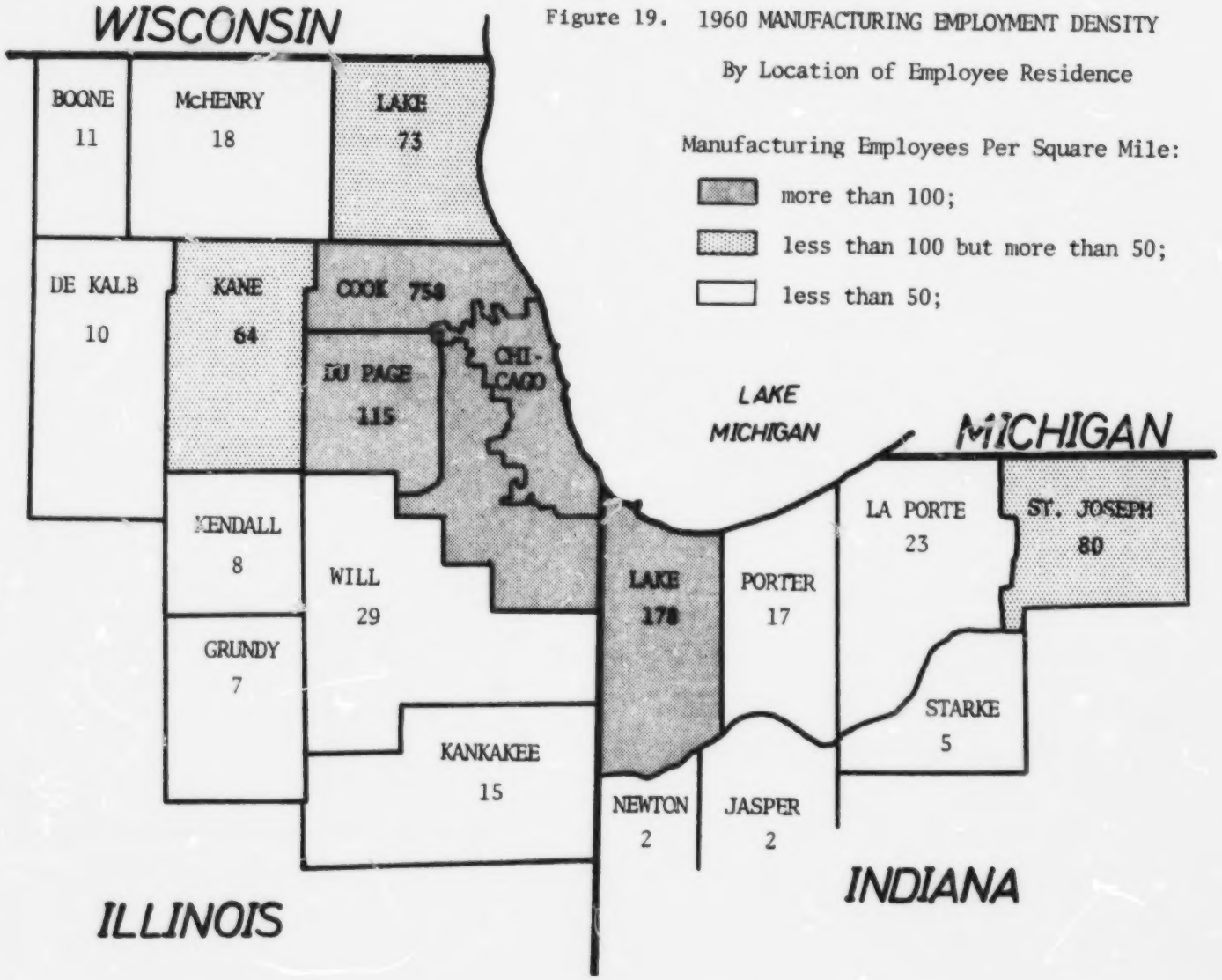


Figure 19. 1960 MANUFACTURING EMPLOYMENT DENSITY

By Location of Employee Residence

Manufacturing Employees Per Square Mile:

- more than 100;
- less than 100 but more than 50;
- less than 50;

apparent that industry is concentrated most heavily in Cook County in Illinois and Lake County in Indiana. Lake and Kane Counties in Illinois also have significant levels of industrial activity. It is interesting to note that due to Elgin and Aurora, Kane County has a heavier industrial base than DuPage, even though DuPage is closer to Chicago. In fact, it appears from comparison of Figure 18 and Figure 19 that many manufacturing employees reside in DuPage but commute to Cook and Kane in order to work. Figure 17 reveals a buffer ring of relatively non-industrial area formed by the outer portions of the eight most urban counties. This buffer ring appears to surround the concentrated industrial areas near the urban centers.

Figure 20 shows the expected absolute growth of manufacturing employment for six counties in Illinois from 1965 to 1995. Table 1 lists the expected increase in manufacturing land use for these six counties. Figure 21 indicates the density of new capital expenditures on manufacturing plant for 1963 by county for the entire Chicago area. Since capital expenditures vary widely from year to year, these last statistics can serve only as approximate indicators of industrial development trends. This series of figures anticipates major industrial growth in Cook and DuPage Counties, with Lake (Illinois) and Kane experiencing moderate industrial growth. Unfortunately, industrial activity forecasts for Indiana by county are not available. However, regarding this topic the Indiana Employment Security Division has forecast important changes in the Porter County economy resulting from the Burns Harbor Port project in that county. According to the forecast,

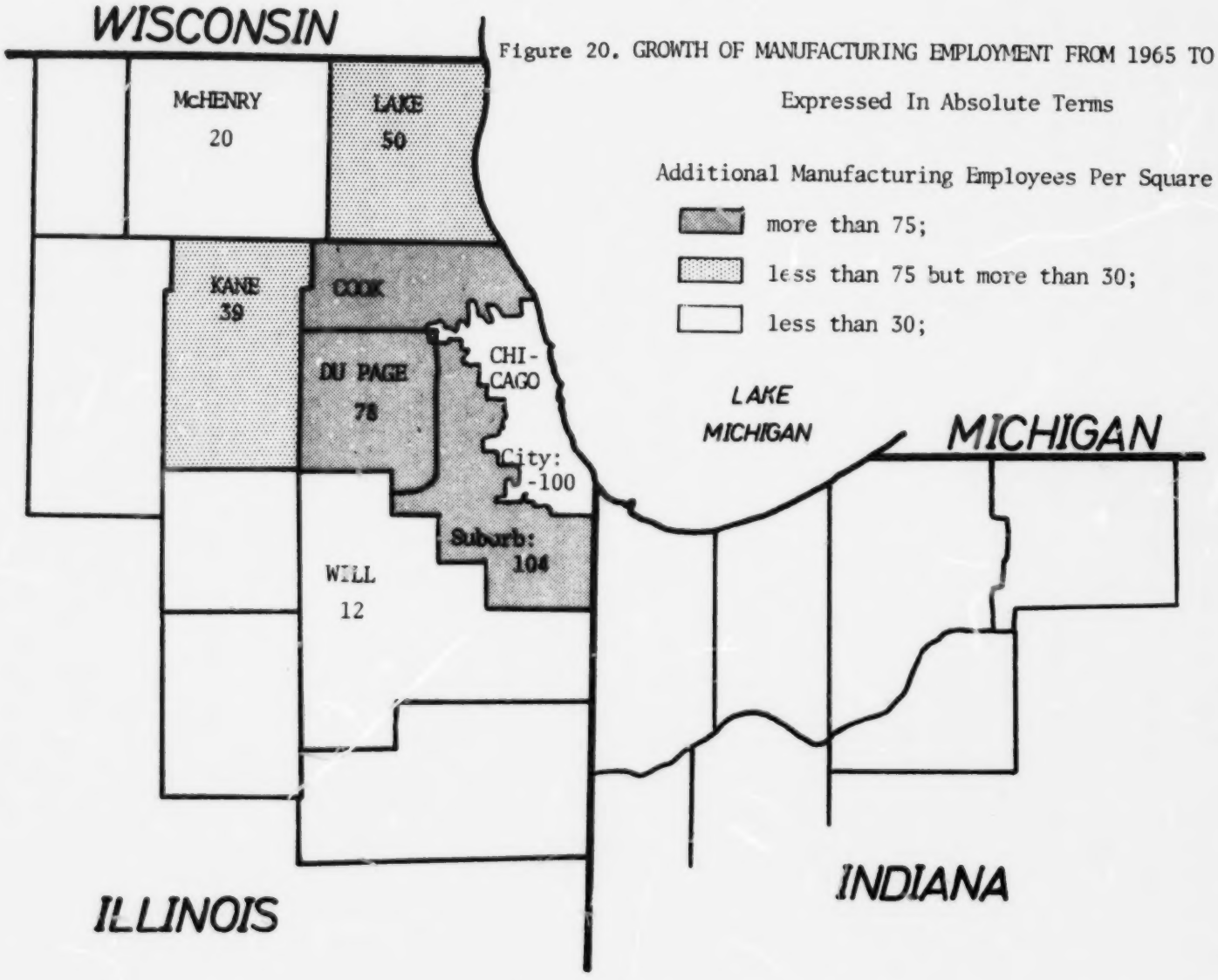


Figure 20. GROWTH OF MANUFACTURING EMPLOYMENT FROM 1965 TO 1995

Expressed In Absolute Terms

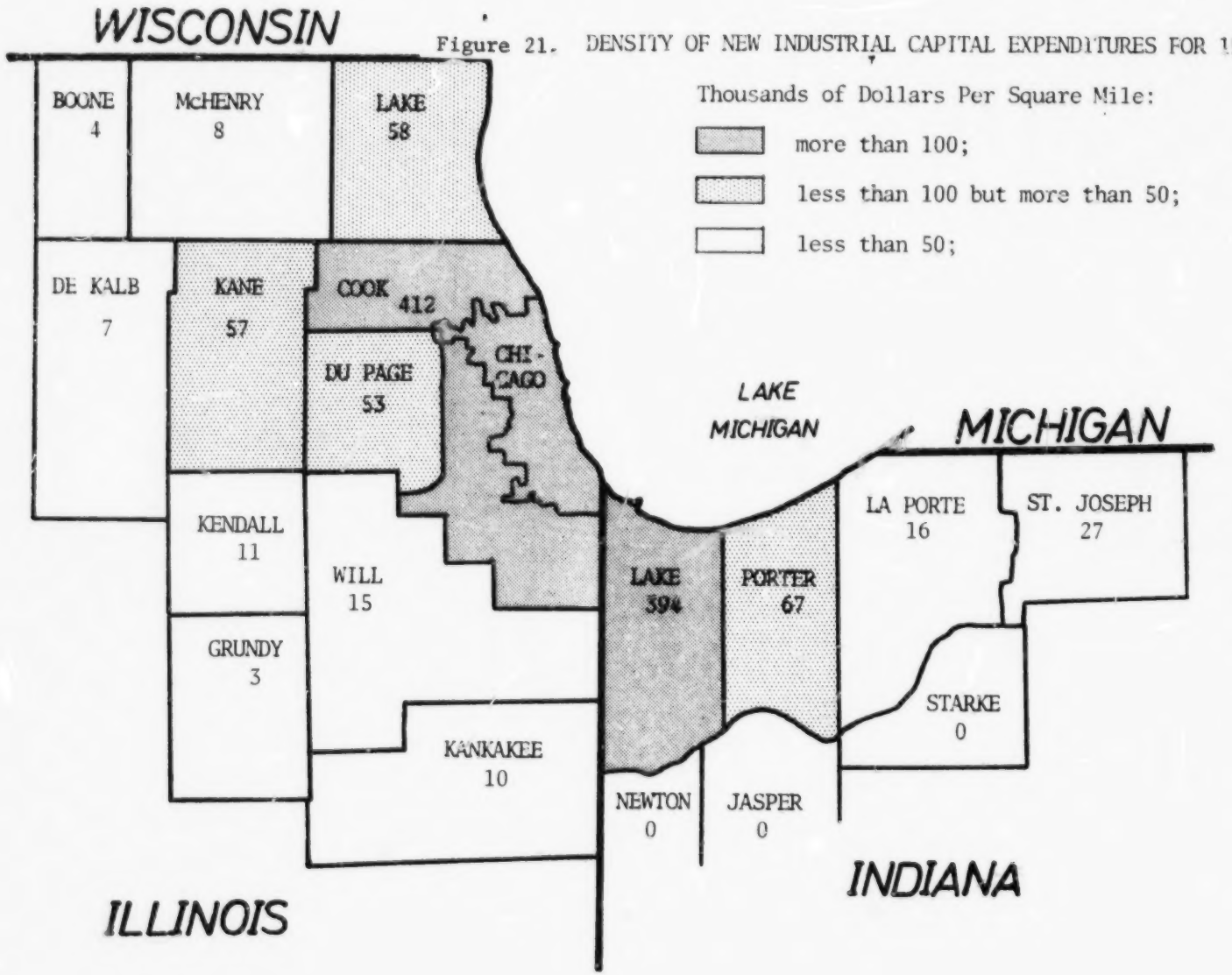
TABLE 1 . MANUFACTURING LAND USE IN NORTHEASTERN ILLINOIS BY COUNTY, 1964 AND PROJECTIONS FOR 1985

MANUFACTURING LAND

COUNTY	Square Miles			Percent Change
	1964	1985	Increase	
Lake	3.3	9.4	6.1	+184.9
McHenry	1.2	5.7	4.5	+375.0
Kane	2.6	10.4	7.8	+300.0
DuPage	2.6	7.2	4.6	+176.9
Will	4.3	7.7	3.4	+ 79.1
Cook	27.5	43.5	16.0	+ 58.2
Postal Zone Chicago	11.0	17.0	6.0	+ 54.5
Suburban Cook	16.5	26.5	10.0	+ 60.6
Northeastern Illinois	41.5	83.9	42.4	+102.2

Source: 1964 Metropolitan Planning Guidelines: Land Use Northeastern Illinois Planning Commission, 1965

Figure 21. DENSITY OF NEW INDUSTRIAL CAPITAL EXPENDITURES FOR 1963



the rural tradition of Porter County will be significantly altered by the Burns Harbor Port. Already Midwest Steel Division of the National Steel Company has announced plans to build a plant in Porter County which will nearly double Midwest's finishing capacity. Bethlehem Steel is planning a completely integrated plant for the Burns Harbor area. These basic steel production plans will attract many associated steel fabricators and manufacturers. The resulting basic industrial base and the port transportation facilities will induce other industrial and commercial enterprises to locate in the Burns Harbor area.

The general conclusion to be drawn from the above data is that the bulk of industrial growth in the Chicago area during the next twenty years will occur in Cook, DuPage, Kane, and Lake Counties in Illinois and in Lake and Porter Counties in Indiana. Growth of heavy industry in Porter County is likely to be especially rapid. Will and McHenry Counties will probably experience moderate industrial growth during the next twenty years. The buffer ring of non-industrialized area mentioned above will probably continue to surround the industrial core areas.

Thus, economic and population forecasts seem to indicate that during the next twenty years most of the residential and industrial development in the Chicago area will take place within seven counties - Lake, Kane, DuPage, Cook, and Will in Illinois, and Lake and Porter in Indiana. McHenry approaches eligibility for this list.

The third condition for air quality control region boundaries requires that they should be compatible with and even foster the development of a governmental unit to administer an effective air

quality control program. Recent developments concerning the Northeastern Illinois Planning Commission (NIPC) and the Lake Porter County Regional Transportation and Planning Commission (hereafter referred to as the Lake Porter Commission) suggest that an eight-county region would be the most natural one for a unified governmental approach to air quality control. These recent events have culminated the gradual emergence of regional planning in the Chicago area over a period of forty years. As early as 1925 the Chicago Regional Planning Association was established as a non-governmental corporation for the purpose of conducting regional studies and coordinating local development plans. The study area of this association included Lake, Porter, and LaPorte Counties in Indiana and three counties in Wisconsin as well as nine counties in Northeastern Illinois. Responding to rapid growth in the Chicago region in the period following World War II, during 1957, the Illinois legislature established the Northeastern Illinois Planning Commission, and granted it authority to conduct research, coordinate development plans, and prepare a comprehensive plan for the six northeast Illinois Counties, McHenry, Lake, Kane, DuPage, Cook, and Will. The Commission's authority is advisory rather than operational in nature. Its findings and proposals do not have binding force on local government. However, NIPC's authority is considerably enhanced by the provisions in section 701 of the Housing Act and 204 of the Model Cities Act, which require that applications for Federal grants under those two programs include an assessment from a designated planning agency of the compatibility of the applicant's plan with existing plans for the planning area. Although the planning agency's approval is not a prerequisite for Federal approval of an

application, the planning agency's assessment is usually a significant factor in the Federal decision. NIPC is financed almost entirely with voluntary appropriations from various governmental units. The Commission does not have taxing power or any source of guaranteed fixed income. During recent years NIPC's annual budget has been somewhat over $400,000; about 50% of the budget has been funded by local government, about 35% by the Federal government, and about 15% by the State of Illinois.

The Lake Porter County Regional Transportation and Planning Commission is NIPC's counterpart on the Indiana side of the State boundary. This Commission was established by State legislation during January 1967. Its authority and responsibilities are similar to those of NIPC: to conduct studies, to review local plans and applications for Federal funds, and to develop a comprehensive plan for the region. The Lake Porter Commission's 1968 budget of $172,000 was financed by a 30 cents per capita tax on residents of Lake and Porter Counties.

During 1967 the Lake Porter Commission and NIPC jointly established and Interstate Coordinating Committee to review plans and applications for Federal funds which have interstate implication. The Coordinating Committee is supported by finances and staff from the two planning agencies. In the course of its one-year existence, it has reviewed a significant number of applications for Federal grants and planning proposals. This year of activity has provided a base for interstate planning cooperation in the future.

In addition, the Chicago Area Transportation Study, an organization which has greatly influenced transportation planning in Chicago since

its inception in 1955, is investigating the possibility of a cooperative agreement with NIPC and the Lake Porter Commission. This cooperative arrangement would provide for joint data acquisition, joint planning efforts, and sharing of staff. These developments indicate a growing interest in and capability for regional planning in the Chicago-Gary area.

In addition to these developments in the regional planning field, there have been two regional studies which have focused specifically on air pollution. From 1957 to 1959 the Indiana State Board of Health and the Illinois Department of Public Health collaborated with Purdue University to produce a report entitled "Bistate Study of Air Pollution in the Chicago Metropolitan Area." The study area included five counties in Illinois (Lake, Kane, Cook, DuPage, and Will) and Lake County in Indiana. The report reviewed the results of previous studies dealing with air pollution in the Chicago area, outlined the existing State legislation applicable to air pollution control, and discussed various emission sources in the area.

From 1964 to 1967 NIPC conducted a study of air pollution in Northeastern Illinois. The report of this study, "Managing the Air Resource in Northeastern Illinois," investigated the five main sources of pollution, the health effects of pollution, the transport of pollution, the measured air quality, the level of public concern, and the relationship between air quality control and comprehensive planning. Commenting on existing air pollution control programs, the 1967 report stated;

> "Under Illinois law, authority to deal with air pollution is divided between municipalities, counties and the state.

"The basic responsibility for the prevention, abatement and control of air pollution throughout the State is vested in the Illinois Air Pollution Control Board...

"Efforts to implement (the Board's) broad powers have been meager. The State budget for the 1965-67 bienium totals $282,000, including $128,000 in Federal grants. On an annual basis this amounts to a little more than ten per cent of the expenditures for air pollution control in the City of Chicago...

"The existing air pollution programs conducted by the six counties range from a small but intensive program in Cook County to almost nothing in several of the other counties. The four basic elements expected to be in an established county program include the adoption and enforcement of a comprehensive ordinance, an annual budget for the program, technical employees, and an adequate number of sampling stations to test air quality...(The 1966 status of programs in the six counties is summarized in Table 2 .)

"Municipal authority to control air pollution is explicitly granted under Chapter 24 of the Illinois Statutes...

"The use of these powers varies widely among the 250 existing cities and villages in the six-county area...

"Chicago, with 3.5 million people, has one of the strongest air pollution control programs in the nation. It has a comprehensive ordinance enacted in 1950 and amended most recently in 1963. It has a budget of nearly $1,271,000 about 30% Federal aid. The technical staff exceeds 75 people, with many different specialities. An extensive pollutant sampling network includes the first telemetered system in the county."

The NIPC report proceeded to cite examples of municpal programs operating with budgets of only a few thousand dollars and no full-time staff.

The Indiana State Air Pollution Control program is operating with a budget of approximately $90,000 during 1968. About half of the budget came from Federal grants. The program supports a staff of eight to ten people. Plans for 1969 call for a budget increase of 50 to 100 per cent.

The Gary City air pollution control program has a budget of

TABLE 2 . COUNTY AIR POLLUTION PROGRAMS IN NORTHEASTERN ILLINOIS, 1966

County	Source of Authority for Air Pollution Control	Current Budget (000)	Technical Staff	Sampling Program		Type of Enforcement
				No. of Stations	Type	
Cook	Specific comprehensive air pollution ordinance enacted 1963	153.5	1 Administrator 1 Chief air pollution supervisor 1 Electrical equipment technician 1 Violations supervisor 5 Inspectors 1 Chemical engineer 1 Statistician and information technician 1 Chemist 1 Laboratory technician	15	SPM	Complaint[d]/ Investigation
DuPage	Specific air pollution ordinance enacted 1963	a/	1 Engineer Some inspection by health department sanitarians	1	SPM Sulf.	Complaint[d]/ Investigation
Kane	County Zoning Ordinance	None	Building Department staff responsible for air pollution control	None	None	Complaint[d]/ Investigation
Lake	General nuisance regulations	None	1/4 to 1/2 of a sanitarian's time	2	SPM	Complaint[d]/ Investigation
McHenry	None b/	None	None	None	None	None
Will	None c/	25c/	No permanent staff 3 Engineers temporary for special survey	11	SPM Dust Sulf.	None

a/Budget part of Health Department budget.
b/Ordinance being drafted.
c/Conducting special survey (with Federal grant) to determine control needs.
d/Enforcement action usually follows from a complaint that is filed.

NOTE: SPM = Suspended Particulate Matter
SO_2 = Sulfur Dioxide
Sulf = Sulfation
Dust = Dustfall

approximately $100,000, of which about 60% is Federal money. In the Gary area (including the cities of Whiting, Hammond, East Chicago, and other parts of Lake County) there are approximately twenty sampling stations, which measure suspended particulates, settled particulates, and SO_2 on a 24 hour basis.

Lake County is supporting a program limited to one part-time sanitary engineer and a budget level of about $10,000. Porter County does not support an air pollution control program at the present time. However, Porter County has contracted with Valparaiso University for a study of air pollution in Porter County in order to determine the extent of the problem.

After reviewing the air resource situation in Northeastern Illinois, the NIPC study made the following program recommendation for air resource management:

> "Air pollution in the Northeastern Illinois-Northwestern Indiana area is a problem of regional scope requiring a regional approach involving the six counties of Northeastern Illinois and two counties of Northwestern Indiana. To implement proper management of the air resource in the region, a coordinated effort by all levels of government - local, State, and Federal - is recommended.
>
> "...The States appear to be the logical organizations to perform region-wide functions. If two separate State programs become the most encompassing regional form attainable, the two operations must be closely coordinated. Basic operating policies, regional air quality goals, air quality sampling, emission standards and enforcement are major activity areas in which consistency and uniformity throughout the region is required.
>
> "In the event that the two States are unwilling or unable to undertake the regional responsibilities, an inter-county regional air conservation agency should be formed, preferably encompassing the eight counties."

Thus, the NIPC report of August 1967 clearly supports a regional air resource management program reaching across State boundaries and

including the area of the eight most urban counties in the Chicago-Gary area.

In 1965, Illinois and Indiana submitted for Congressional approval an Interstate Compact for the control of interstate air pollution. The provisions of this compact established an interstate commission and charged it with responsibility to set standards and to enforce those standards through court action. Although this compact has met with some difficulties, it is another indication of the cooperative spirit which extends across the State line between Indiana and Illinois.

In view of the interstate cooperation and regional planning activities noted above, as well as the recommendations of the regional air quality study, an air quality control region which encompasses eight counties would appear to form a natural unit for existing governmental jurisdictions and planning activities. Although the counties and smaller political subdivisions within this area have air pollution control programs of widely varying effectiveness, regional data, regional planning and regional cooperation have developed to an advanced level in an eight county area. For these reasons, that eight county area seems to best satisfy the third condition of air quality control region boundaries: that they are compatible with and even foster a unified governmental administration of an effective air quality control program.

In conclusion, urban factors seem to indicate that an eight-county area, consisting of Lake, Kane, McHenry, Will, DuPage, and Cook in Illinois and Lake and Porter in Indiana, would form the most appropriate air quality control region. At the present time the population density

and industrial activity level in McHenry, Will, and Porter are quite low. However, suburban expansion westward from Chicago will begin to alter McHenry and Will Counties during the next ten to twenty years. And, rapid industrial development in Porter will accompany sharp population growth eastward from Gary.

Counties bordering the eight-county area have low population density and industrial activity at the present time, and are likely to experience low growth rates during the next twenty years.

The regional data, cooperation and communication fostered by NIPC and the Lake Porter County Regional Transportation and Planning Commission are strong arguments in favor of an eight-county region. Ultimately, it is the will and ability of governmental units to work cooperatively and aggressively that will determine the success or failure of air quality control in the Chicago-Gary area. The eight-county area is the one most likely to succeed in this respect.

Note 1--Sources and Procedures for the Population Projections

The 1960 population figures are from the 1960 census. The Rand McNally Commercial Atlas and the Hospital Planning Council for Metropolitan Chicago have developed estimates for 1968 population by county. These figures were published in 1968. However, the Hospital Planning Council estimates cover only the Chicago Standard Consolidated Area; i.e. McHenry, Lake, Kane, Cook, DuPage, Will in Illinois, and Lake and Proter in Indiana. These 1968 population estimates are based on housing starts, birth and death rates, and other factors. The Rand McNally figures compare closely with these of the Hospital Planning Council (less than plus or minus 3% difference). Since the Rand McNally estimates covered a larger area, they were used in order to calculate the population growth rate for the decade 1960-1970, the 1960-1968 growth rate was multiplied by 5/4. This method implicitly assumes a linear growth pattern for population. Although such an assumption is subject to criticism, it provides a reasonable estimate for population growth during the decade. For example, even if one assumes an exponential growth pattern for population, the growth for the decade would be larger by only zero to five percent.

Population growth estimates for the decades 1970-1980, 1980-1990 came from two sources. The Indiana projections were published during 1968 by the Indiana State Department of Natural Resources as part of the State Water Plan. These projections relied upon earlier studies, especially the Indiana University Study published in 1966. The forecasts for McHenry, Lake, Cook, DuPage, Kane, and with counties in Illinois were prepared during 1968 by Northeastern Illinois Planning Commission;

they are still subject to review and revision before final publication. These forecasts were developed for the ten year periods 1965-1975, 1975-1985, and 1985-1995. In order to have forecasts for time periods corresponding to the Indiana projections, growth rates for 1970-1980 and 1980-1990 were calculated according to the equations:

$$\left[\text{growth}_{1970\text{-}1980}\right]^2 = \left[\text{growth}_{1965\text{-}1975}\right] \cdot \left[\text{growth}_{1975\text{-}1985}\right]$$

$$\left[\text{growth}_{1980\text{-}1990}\right]^2 = \left[\text{growth}_{1975\text{-}1985}\right] \left[\text{growth}_{1985\text{-}1995}\right]$$

In other words, the geometric averages were calculated. This procedure is subject to criticism. However, the approximate growth forecasts which result satisfy the present requirements for heuristic rather than definitive data. The forecasts for other counties in Illinois were published during 1967 by the Department of Business and Economic Development of the State of Illinois.

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APPENDIX A. EMISSION INVENTORY

The following information is the result of a rapid emission inventory[1] of air pollutant sources in the Metropolitan Chicago area. The objectives of this study were to determine the total quantities of various air pollutants emitted, using appropriate emission factors,[2] and to estimate the geographical and seasonal variation in air pollutant emissions. To accomplish this task, the Study area was divided into a grid coordinate system and the emission quantities were reported in terms of tons of pollutant per grid on an average annual day, average summer day, and average winter day.

The pollutants considered in this survey are sulfur oxides, particulates, and carbon monoxide. The emissions of other pollutants were not estimated due to a limitation of time, personnel, and available data. Data presented herein are for the most part representative of 1967 and were originally gathered by the acknowledged State and local agencies.

The study area included six counties in Northeastern Illinois (Lake, Cook, Will, McHenry, Kane, and Dupage), and two counties in Northwestern Indiana, (Lake and Porter).

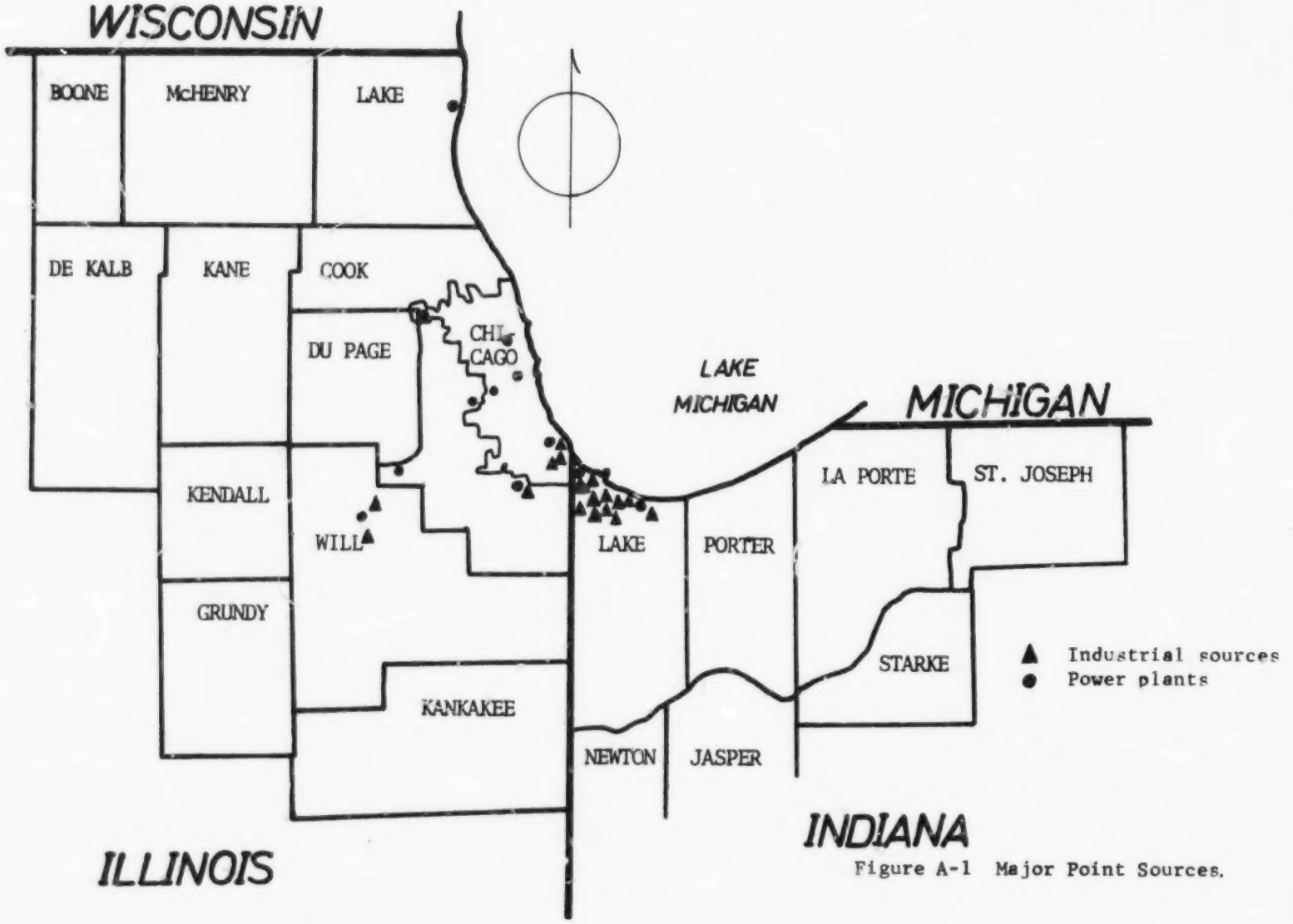


Figure A-1 Major Point Sources.

Table A-1
PARTICULATE EMISSIONS BY SOURCE CATEGORY IN THE
CHICAGO-GARY METROPOLITAN AREA, 1966-1967
TONS/YEAR

City or County	Fuel Combustion					Industrial Process	Refuse Disposal	Transportation	Total
	Residential	Commercial	Industrial	Power Plants	Total Fuel				
Cook	6000	36700	28100	6300	77100	12000	4600	5900	99600
Chicago	13000	23600	32900	9500	79000	44000	14000	9700	146700
DuPage	600	7000	5000	-	12600	300	900	630	14430
Kane	730	4600	4300	-	9630	600	600	370	11200
Lake	630	440	4300	3300	8670	300	840	530	10340
McHenry	220	1500	1500	-	3220	300	240	160	3920
Will	900	3700	3200	11000	18800	300	550	340	19990
Subtotal (Illinois)	22080	77540	79300	30100	209020	57800	21730	17630	306180
Lake	330	1900	1500	-	3730	-	1300	340	5370
Gary	650	650	9500	9030	19830	120000	1700	250	141780
Hammond	460	450	3600	9300	13810	50	1000	340	15200
E. Chicago	350	210	22000	-	22560	87300	90	170	110120
Whiting	60	30	3900	-	3990	1500	40	20	5550
Porter	180	970	460	-	1610	-	50	110	1770
Subtotal (Indiana)	2030	4210	40960	18330	65530	208850	4180	1230	279790
Area Total	24110	81750	120260	48430	274550	266650	25910	18860	585980

Table A-2
CARBON MONOXIDE EMISSIONS BY SOURCE CATEGORY IN THE CHICAGO-GARY METROPOLITAN AREA, 1966-1967
TONS/YEAR

City or County	Fuel Combustion					Industrial Process	Refuse Disposal	Transportation	Total
	Residential	Commercial	Industrial	Power Plants	Total Fuel				
Cook	11400	37800	1500	400	51100	n.a.*	9100	745000	805200
Chicago	26800	22400	1900	800	51900	n.a.	34500	905000	991400
DuPage	770	7100	280	-	8150	n.a.	1800	153000	162950
Kane	1400	4500	240	-	6140	n.a.	1100	91000	98240
Lake	800	450	240	400	1890	n.a.	1700	127000	130590
McHenry	300	1500	80	-	1880	n.a.	480	39000	41360
Will	1900	3600	180	1800	7480	n.a.	1200	82000	90680
Subtotal (Illinois)	43370	77350	4420	3400	128540	n.a.	49880	2142000	2320420
Lake	80	1860	530	-	2470	-	2300	86000	90770
Gary	1200	560	560	280	2600	-	3000	64000	69600
Hammond	870	390	180	300	1740	-	1800	88000	91540
E. Chicago	660	180	1400	-	2240	60200	420	46000	108860
Whiting	100	30	200	-	330	6600	80	6500	13510
Porter	30	930	340	-	1300	-	900	29000	31200
Subtotal (Indiana)	2940	3950	3210	580	10680	66800	8500	319500	405480
Area Total	46310	81300	7630	3980	139220	-	58380	2461500	2725900

*n.a. - not available

Table A-3
SULFUR OXIDE (SO_x) EMISSIONS BY SOURCE CATEGORY IN THE CHICAGO-GARY METROPOLITAN AREA, 1966-1967
TONS/YEAR

City or County	Fuel Combustion					Industrial Process	Refuse Disposal	Transportation	Total
	Residential	Commercial	Industrial	Power Plants	Total Fuel				
Cook	80000	71000	68300	101000	320300	n.a.*	840	2300	323440
Chicago	62600	56000	92700	201000	412300	n.a.	1400	3500	417200
DuPage	14900	14100	12100	-	41100	n.a.	170	470	41740
Kane	3700	8900	10600	-	23200	n.a.	100	280	23580
Lake	3700	820	10600	112000	127120	n.a.	160	400	127680
McHenry	1200	2900	3500	-	7600	n.a.	40	120	7760
Will	4300	1100	7800	458000	471200	n.a.	110	260	471570
Subtotal (Illinois)	170400	154820	205600	872000	1402820	n.a.	2820	7330	1412970
Lake	2100	4700	3300	-	10100	-	20	270	10390
Gary	4400	1900	32900	74500	113700	-	30	200	113930
Hammond	3100	1300	7400	75000	86800	18000	20	270	105090
E. Chicago	2400	570	89800	-	92770	18000	5	140	10915
Whiting	400	100	8800	-	9300	13000	-	20	22320
Porter	1100	2300	1200		4600	-	10	90	4700
Subtotal (Indiana)	13500	10870	143400	149500	317270	49000	85	990	367345
Area Total	183900	165690	349000	1021500	1720090	49000	2905	8320	1780315

*n.a. - not available.

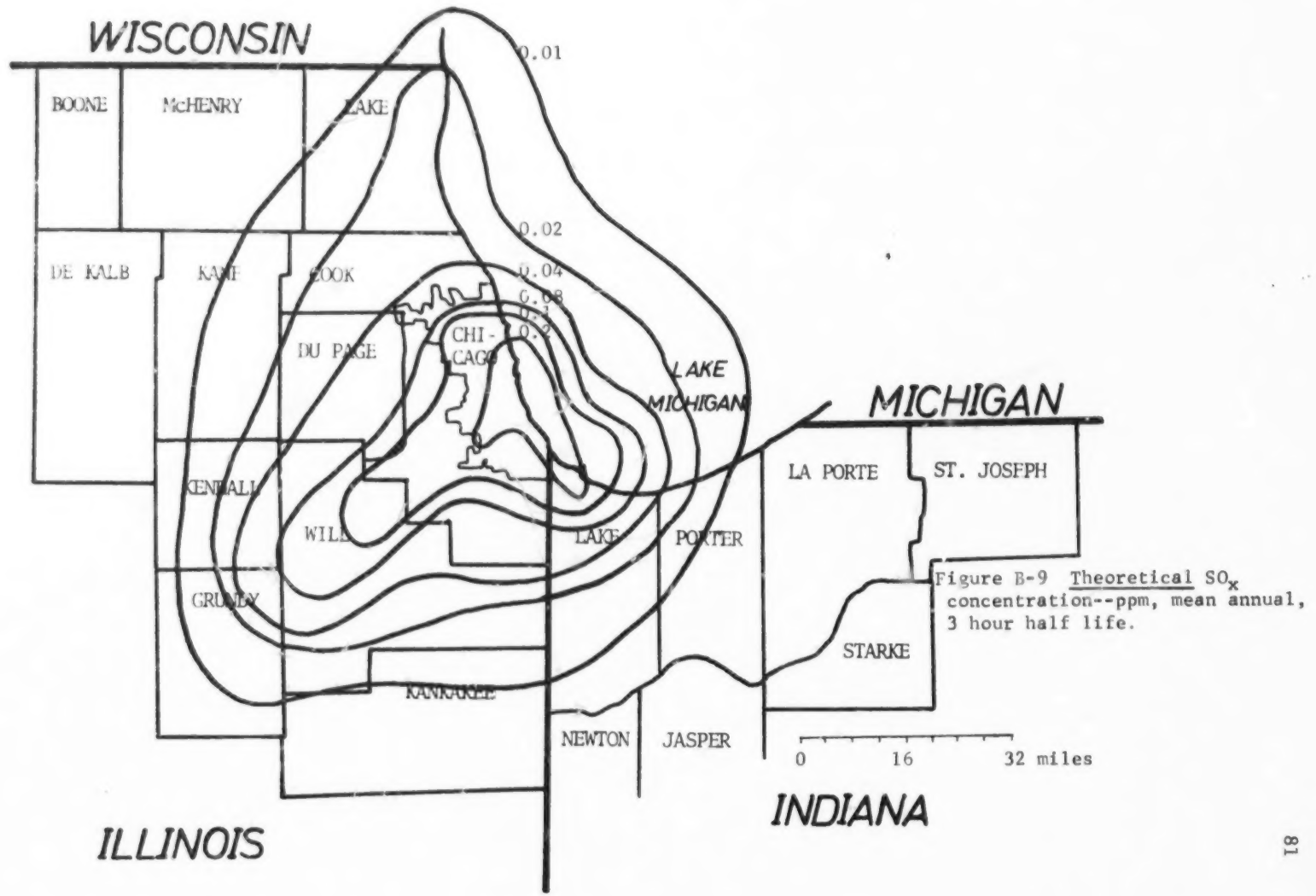


Figure B-9 Theoretical SO_x concentration--ppm, mean annual, 3 hour half life.

Table A-4
MEAN DAY EMISSIONS FOR VARIOUS AVERAGING TIMES
(CHICAGO-GARY METROPOLITAN AREA)
(TONS)

County	Sulfur Dioxide			Carbon Monoxide			Particulate		
	Annual	Winter	Summer	Annual	Winter	Summer	Annual	Winter	Summer
Cook	3192	4015	2524	4903	4679	5017	850	1251	531
Dupage	138	255	43	449	429	459	99	133	71
Kane	54	95	20	269	260	272	36	56	20
Lake	43	65	26	122	118	124	18	24	14
McHenry	21	37	9	116	109	118	14	20	--
Will	188	346	76	243	234	247	145	185	112
Subtotal (Illinois)	3636	4813	2698	6102	5829	6237	1162	1769	748
Lake	1308	1508	1142	1022	951	1066	808	882	746
Porter	13	24	3	85	80	89	5	9	2
Subtotal (Indiana)	1321	1532	1145	1107	1031	1155	813	891	748
Area Totals	4957	6345	3843	7209	6860	6392	1975	2660	1496

References for Appendix A.

1. "Rapid Survey Technique for Estimating Community Air Pollution Emissions," PHS, Publication No. 999-AP-29, Environmental Health Series, USDHEW, NCAPC, Cincinnati, Ohio, October 1966.

2. Duprey, R. L., "A Compilation of Air Pollution Emission Factors," USDHEW, PHS, BDPEC, NCAPC, Durham, North Carolina, 1968.

APPENDIX B. AIR QUALITY ANALYSIS

Title I, Section 107(a)(2) of the Air Quality Act of 1967 (Public Law 90-148, dated November 21, 1967), calls for the designation of air quality control regions, based on a number of factors, including "atmospheric conditions," interpreted to mean that the boundaries of air quality control regions should reflect the technical aspects of air pollution and its dispersion. Within this guidelines, however, the position has been taken that region boundaries cannot be based on an extreme set of circumstances which might have a theoretical chance of occurrence. Hence the analysis of a region's atmospheric dilution potential is largely based on mean annual values, although summer and winter mean values are analyzed with respect to reviewing seasonal variations in meteorology and pollutant emissions.

With the realization that the meteorological analysis would help define tentative boundaries only and that final boundaries would be developed subsequently to reflect local government aspects, it was decided that the meteorological assessment should be as unpretentious as possible. Accordingly, the widely accepted long-term Gaussian diffusion equation, described by Pasquill[1] and Turner[3], has been applied with a few modifications[2] for application to the multiple-source situation of an urban area, inherent to the delineation of air quality control regions. The basic equation assumes that the concentration of a pollutant within a plume has a Gaussian distribution about the plume centerline in the vertical and horizontal directions, with the standard deviations in the two directions being a function of distance from the

source, certain characteristics of mixing layer, collectively referred to as "stability class." Graphs have been developed which give (σ_z vertical and σ_y (horizontal) diffusion co-efficients versus stability class and distance downwind. Reference 5 describes the Gaussian-based diffusion model and the inherent assumptions made when it is applied. In summary, the Gaussian diffusion equation is utilized to provide a theoretical estimate of the geographical distribution of long-period mean ground-level concentrations of SO_x, CO, and suspended particulates. The model used has the necessary flexibility to utilize information on emissions from both point and area-wide sources.

To maintain simplicity, all pollutant sources were assumed to be at ground level; for CO this assumption is realistic. The same assumption is used for major point sources of SO_x and particulates, since the distances of interest are sufficiently great to obviate the source-height effect for most receptors. A three hour half life for SO_x was arbitrarily selected for comparison. No deposition term was applied to the evaluation of suspended particulate concentration distributions.

METEOROLOGICAL DATA INPUT

The meteorological data input to the model is screened to determine the representativeness of the data. Appropriate surface wind rose data are selected from U.S. Weather Bureau records; if necessary, special wind data tabulations are obtained from the National Weather Records Center (NWRC). The mean mixing depth for each region, for each respective time period (seasonal and average), is determined on the basis of computed mixing depths documented by Holzworth[4,5] and recent tabulations

furnished the Meteorology Program by the National Weather Records Center (ESSA).

The diffusion model was applied for each of the three pollutants for the three different time periods--annual, winter, and summer. Figure B-1 and Table B-1 show the meteorological data required to apply the model for each of the three time periods.

Figure B-1 shows the percent frequency of occurrence of wind direction from 1951 through 1960 at the Midway Airport for summer, winter, and annual conditions.

From an analysis of available wind rose data in the Chicago area, the wind data from Midway Airport was selected as adequately representing prevailing wind patterns throughout the area.

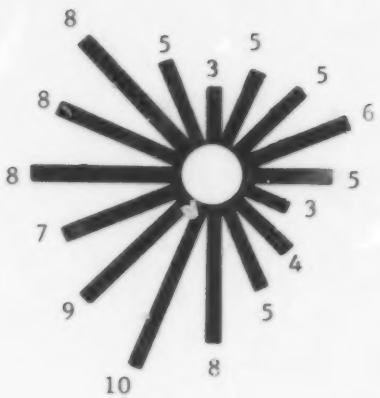
The mixing depths for these time periods are an average of the mean daytime and mean nighttime values as shown in Table B-1.

Table B-1
Average Mixing Depths for the Chicago-Gary Area by Season

SEASON	Mixing Depth, Meters		
	Morning Average	Afternoon Average	Average
Winter (Dec., Jan., Feb.)	372	642	507
Summer (June, July, Aug.)	309	1601	955
Annual	349	1193	771

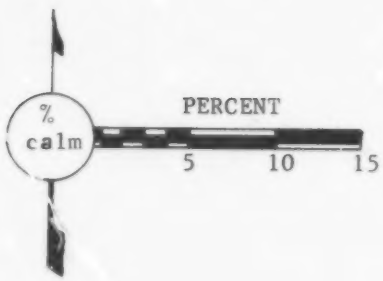
Using the foregoing information with emissions data, concentrations were calculated for each of the three pollutants for each of the three time

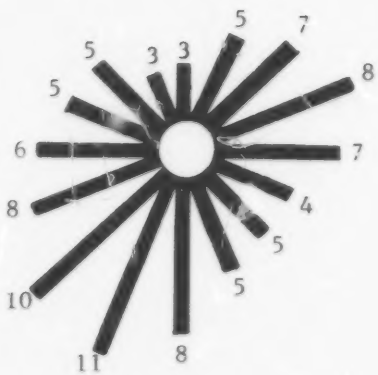
periods at a total of 97 ground-level receptor points at each of the 16 compass points (20, 30, 40, 50, 70, and 100 kilometers from an assumed center point located at City Hall in downtown Chicago). The theoretical concentrations estimated by this process are in addition to "background" levels since the model was not supplied with information on sources located outside the area initially surveyed. The results are presented in Fugures B-2 through B-11, Appendix B, as theoretical concentrations and are discussed in the basic part of the report.



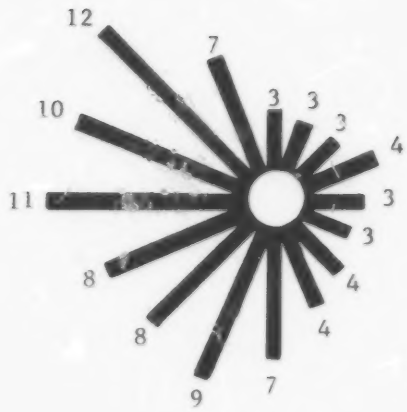
ANNUAL

Figure B-1 Percent frequency of wind direction for various averaging times, based on 1951-60 data from Midway Airport.





SUMMER
(June, July, August)



WINTER
(December, January, February)

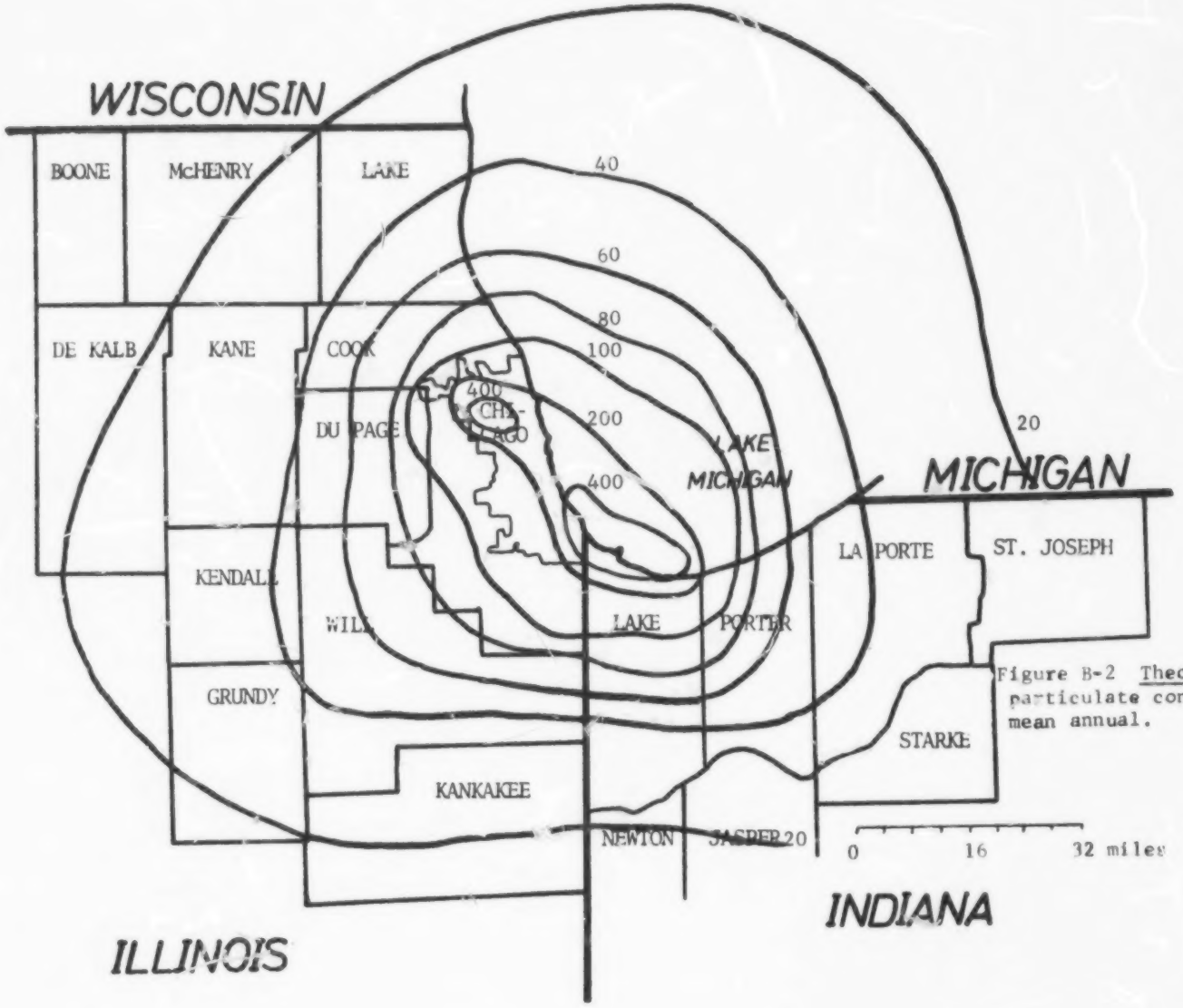


Figure B-2 Theoretical particulate concentration--$\mu g/m^3$, mean annual.

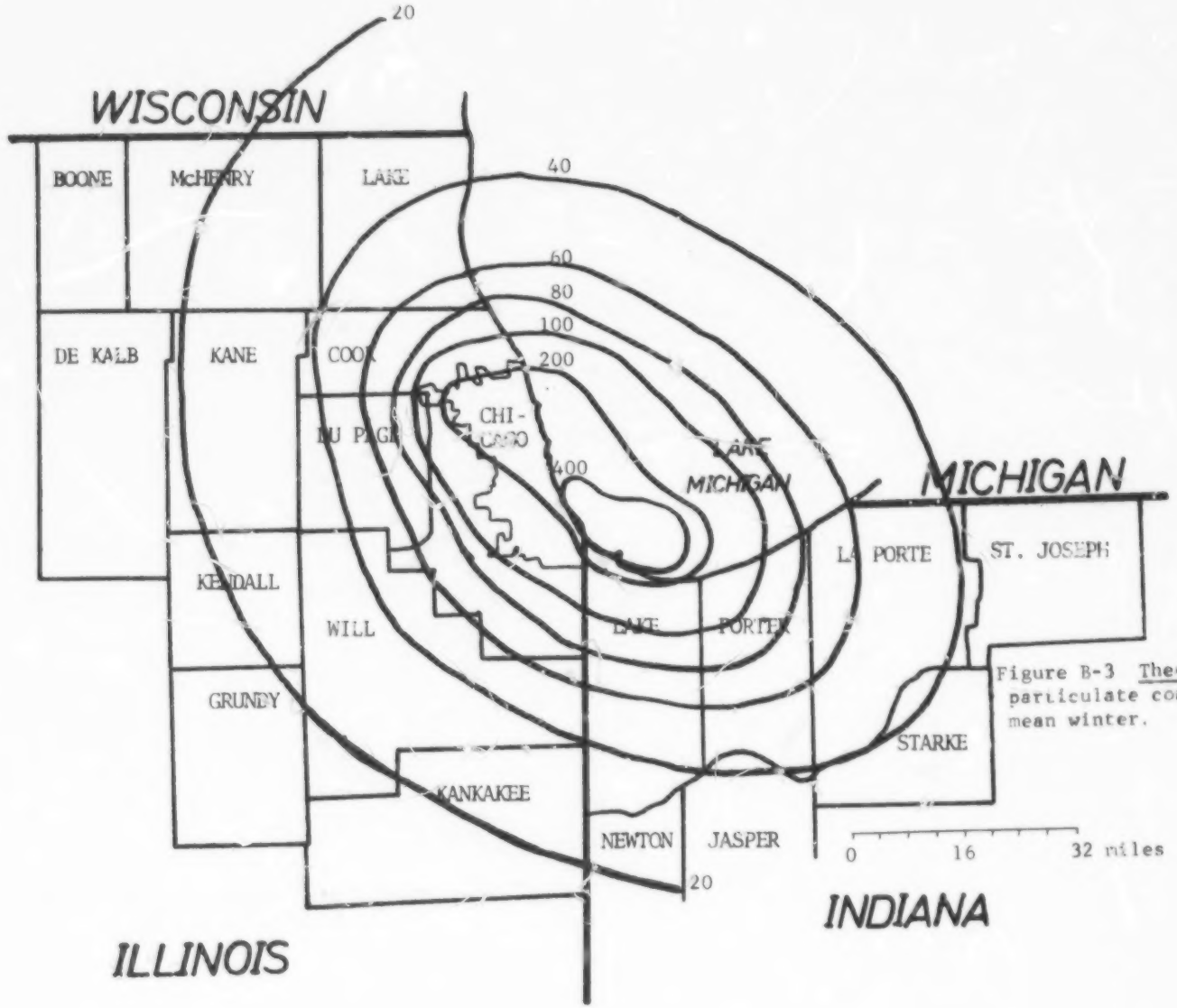


Figure B-3 Theoretical particulate concentration--$\mu g/m^3$, mean winter.

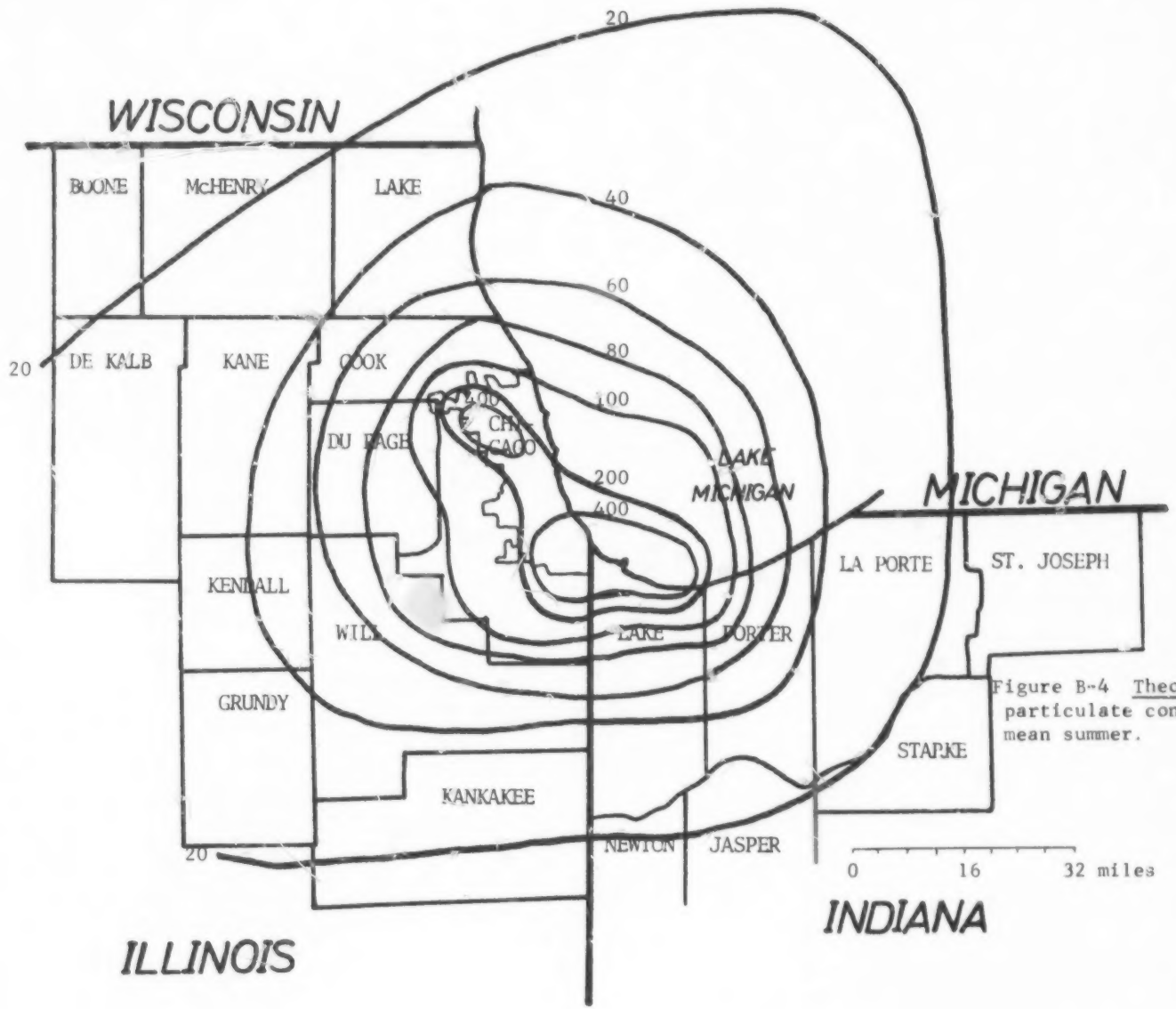


Figure B-4 Theoretical particulate concentration--$\mu g/m^3$, mean summer.

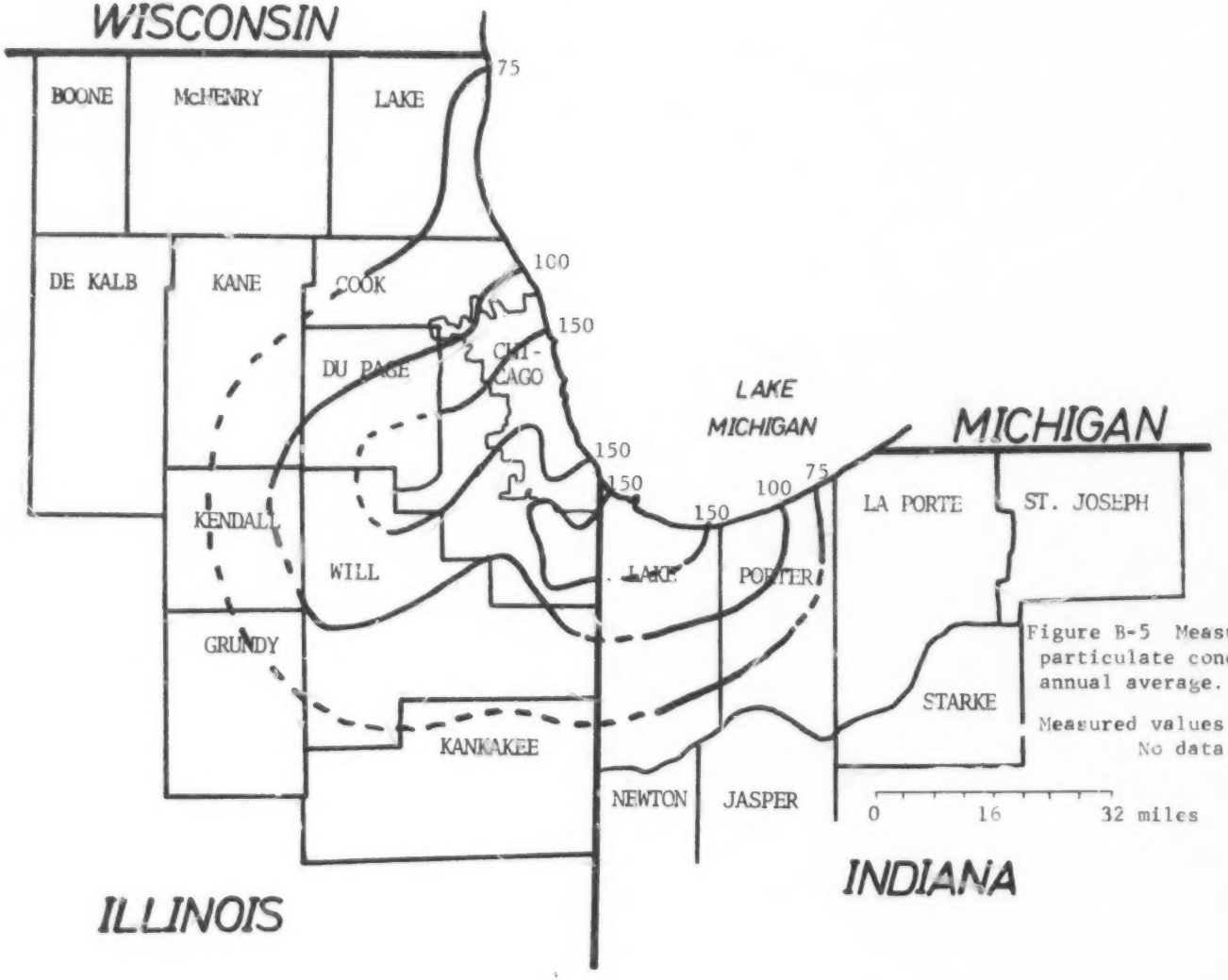


Figure B-5 Measured suspended particulate concentration--$\mu g/m^3$, annual average.

Measured values ——

No data ------

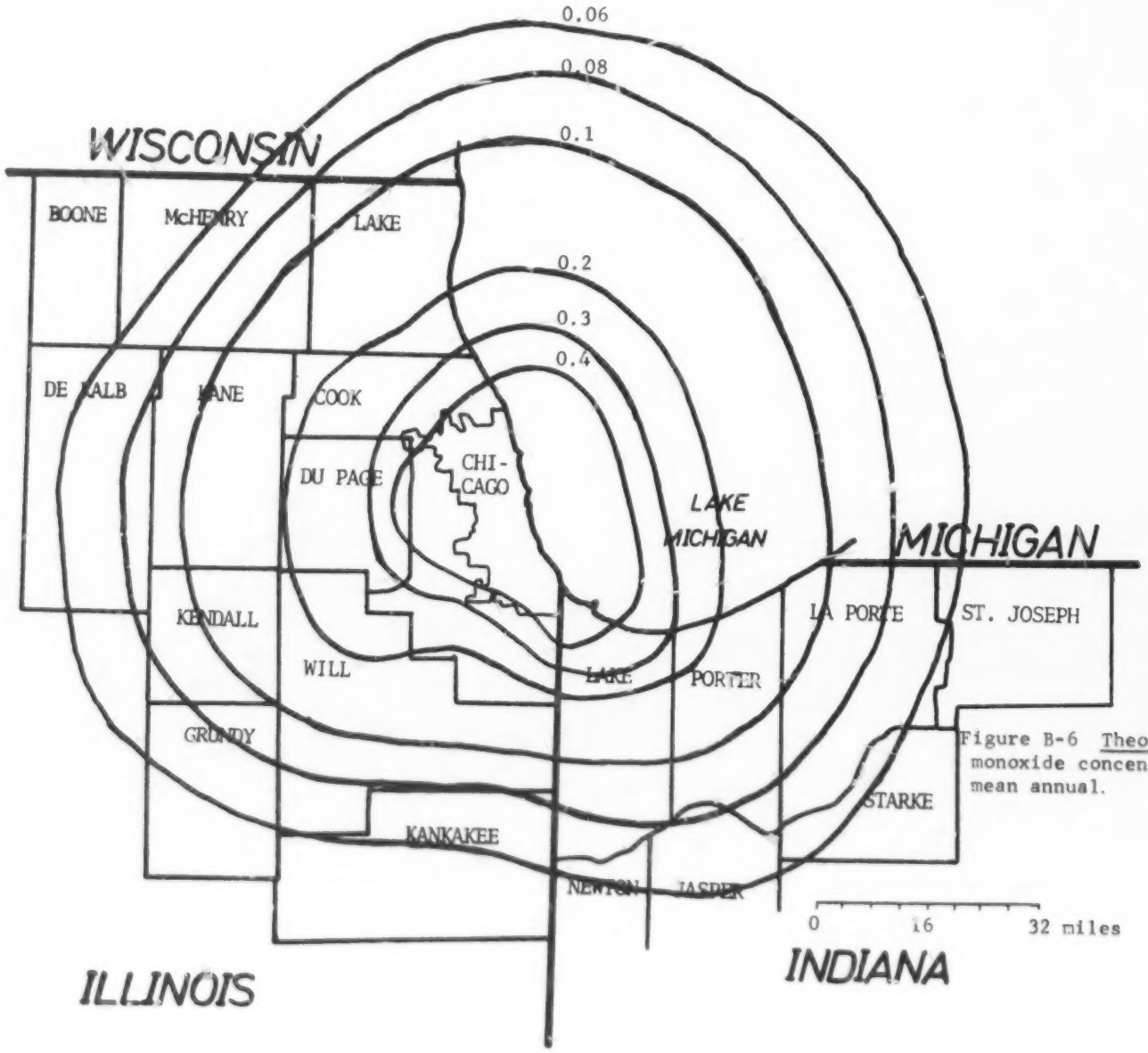


Figure B-6 Theoretical carbon monoxide concentration--ppm, mean annual.

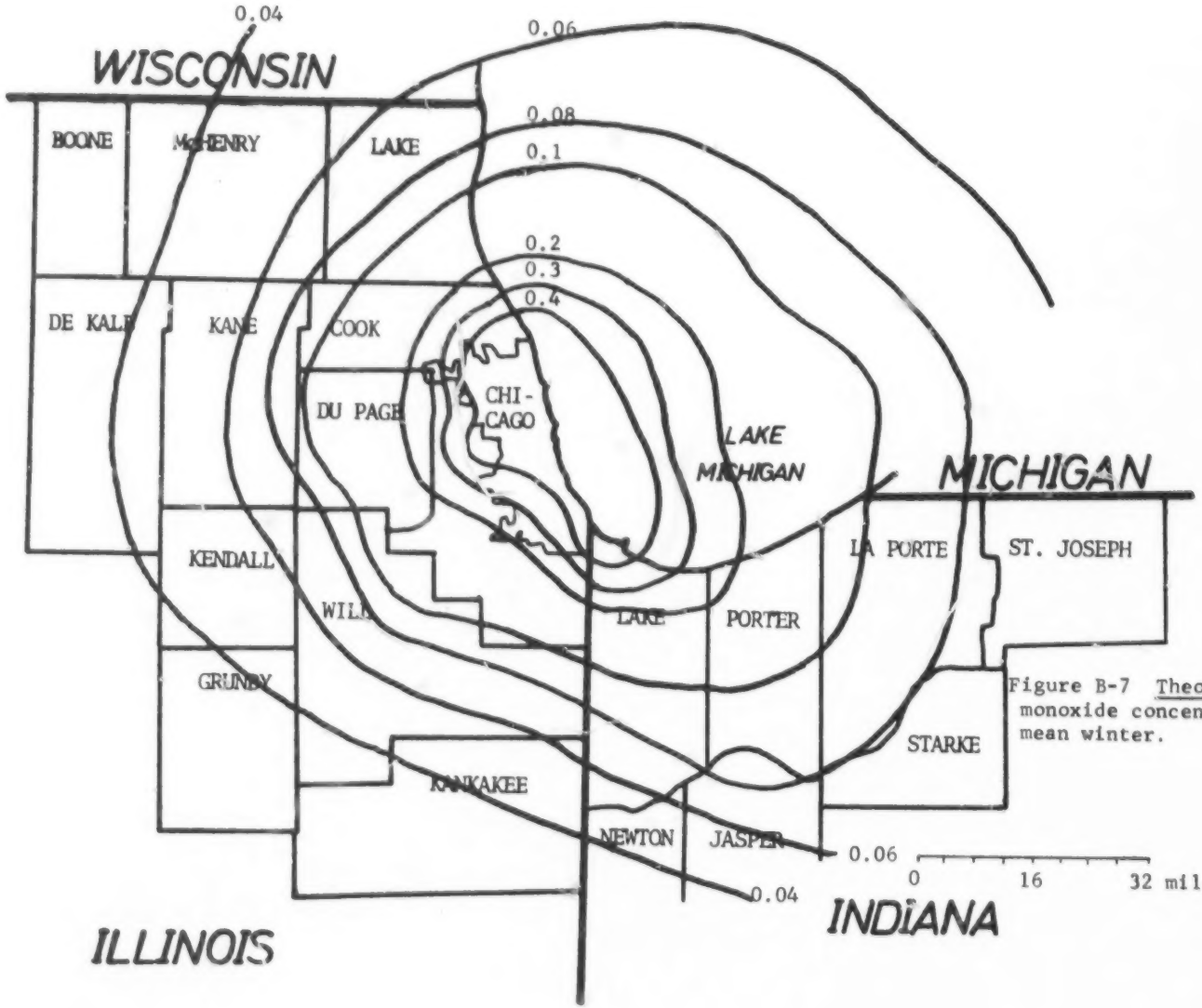


Figure B-7 Theoretical carbon monoxide concentration--ppm, mean winter.

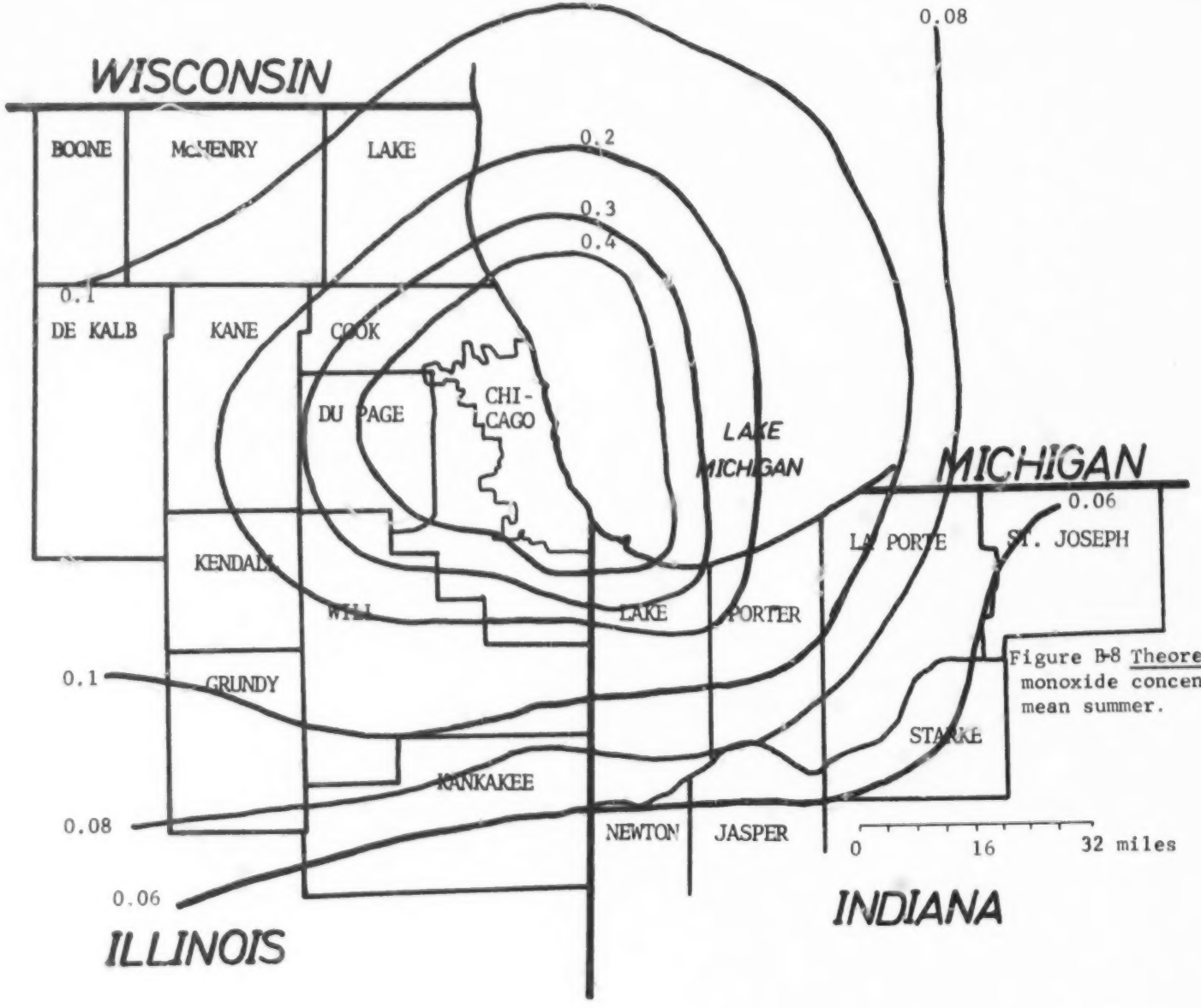


Figure B-8 Theoretical carbon monoxide concentration--ppm, mean summer.

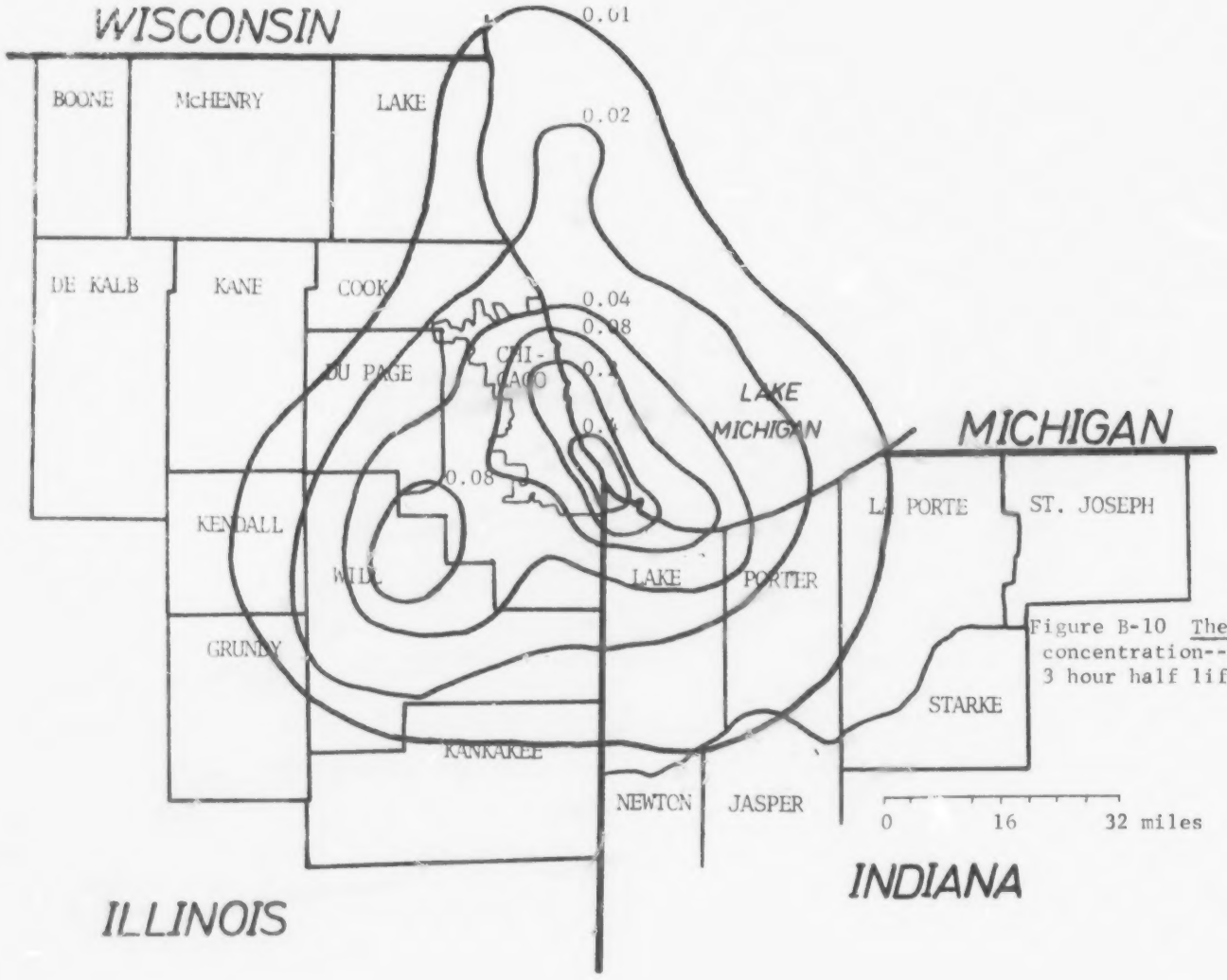


Figure B-10 Theoretical SO_x concentration--ppm, mean winter, 3 hour half life.

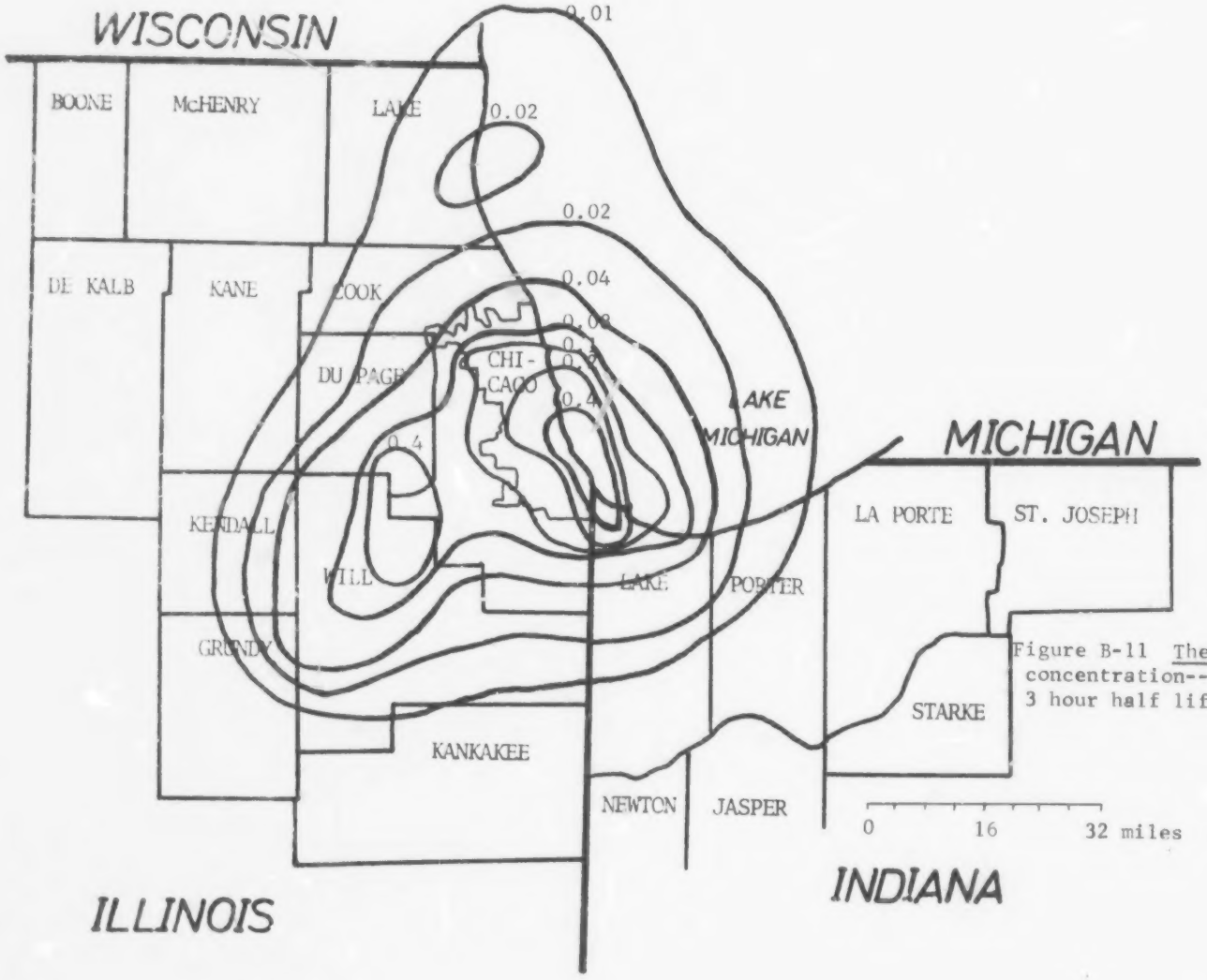


Figure B-11 Theoretical SO_x concentration--ppm, mean summer, 3 hour half life.

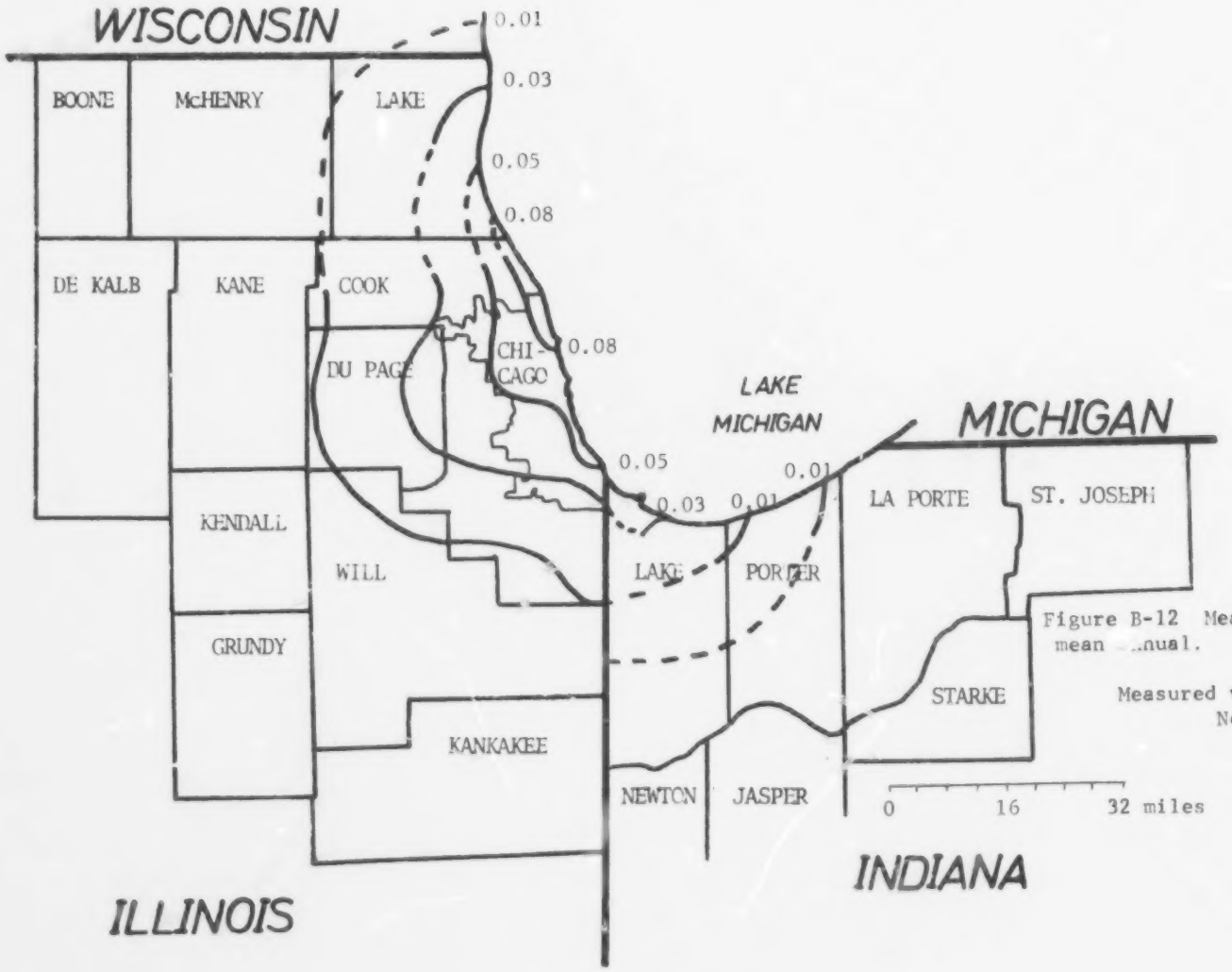


Figure B-12 Measured SO_2--ppm, mean ..nual.

Measured values ———
No data -------

References for Appendix B.

1. Pasquill, F., "The Estimation of the Dispersion of Windborn Material," Meteorology Magazine, 90, 1963, pp. 33-49.

2. Martin, D. O., Tikuart, J. A., "A General Atmospheric Diffusion Model for Estimating the Effects on Air Quality of One or More Sources," paper no. 68-148, 61st Annual Meeting, APCA, St. Paul, Minnesota, June, 1968.

3. Turner, D. B., "Workbook of Atmospheric Dispersion Estimates," USDHEW, Cincinnati, Ohio, 1967.

4. Holzworth, G. C., "Mixing Depths, Wind Speeds and Air Pollution Potential for Selected Locations in the United States," J. Appl. Meteor., No. 6, December, 1967, pp. 1039-1044.

5. Holzworth, G. C., "Estimates of Mean Maximum Mixing Depths in the Contiguous United States," Mon. Weather Rev. 92, No. 5, May, 1964, pp. 235-242.

* U.S. GOVERNMENT PRINTING OFFICE : 1968